Metals and Alloys

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Articles

Metallurgical Engineering Digest

Feature Section

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More steel ingots from the all-basic open-hearth.—Reinartz, page 438.

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How the present pressure of demand can be partially met by increased duplexing with the Bessemer.—Graham, page 442.

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Increased output and reduced costs obtained by mechanized oxy-acetylene welding.—Rockefeller, page 465.

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Simplify our groups of steels in the interest of speedier production.—Smith, page 483.

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Faster production promoted by improving the machinability of cast iron.—Lorig, page 486.

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How mass radiographic inspection promotes defense production.—Woods, page 508.

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More speed in production by means of rapid analyses by spectrography.—Nitchie, page 509.

Engineering Digests

Welder Qualification

The gentle hand of Order is applied to the chaotic welder-qualification picture through an American Welding Society. Committee report on standards for welders to meet in qualification tests, abstracted on p. 590.

Plating Aluminum on Steel

Aluminum-on-steel coatings would have several important industrial applications if electrolytic methods of making them could be perfected. A comprehensive review of the problems and progress in this field is given on p. 586.

Heat Treating High Speed Steel

A monumental paper by Schlegel (p. 602) reveals that soft skin on heat-treated high speed steel may be caused by *carburization* rather than *decarburization*. Perhaps some of our pet ideas about atmospheres are due for the discard.

All Metals are Precious

Nowadays platinum, gold, etc., are just "noble" metals—*all* metals are "precious." The current metal-supply situation and substitutions adopted by metallurgical design engineers to offset and alleviate critical-metal shortages are broadly presented in a composite on p. 620.

Cast vs. Rolled vs. Welded Stainless

Occasionally we've been charged with overemphasizing the design problem involved in selecting metal-forms—deciding whether it's best to use a casting or a forging or a weldment or what-have-you for a specific product or service. But the problem *can't* be overemphasized; too little published guidance on the matter has been offered the engineer, yet it is one of the commonest phases of metallurgical design. That's why we'll continue to highlight any good article on the subject, such as that of Ostrom and Thomas *re* stainless (p. 632).

Modern Condenser-Tube Alloys

According to an A.S.M.E. committee report (p. 636), the "good old" condenser tube alloys—Admiralty, Muntz metal and arsenical copper—are being outperformed by the newer alloys such as aluminum brass, aluminum bronze, copper-nickel, copper-nickel-zinc and copper-nickel-tin.

Our Special Issue

The present World War is a War of Metals. Without metals and their alloys, the conflict could not be fought.

Both for this nation's own defense and for aid to the democracies, metals in many, many forms are absolutely necessary. And the faster and in the greater abundance they can be furnished to the Army, the Navy and the Air Force, victory is the better assured.

To help the metal industries and those in charge of the Defense Program, this issue is specially devoted to some of those processes and methods which, in the experience of a group of authorities, are instrumental in promoting—

Faster Production for Defense

These contributions should be of value to the Defense Program. The editors acknowledge with gratitude the cooperation of the contributors.—The Editors.

Once Again

The "I am holier than thou" attitude of some of the high-brow literary magazines that smugly tell what's wrong with the world and how to fix it, especially in sociological matters, has long griped us.

Finding an article on "Plywood, the Lumberman's Stepchild," in the September *Harpers,* brought the thought that perhaps here would be an article phrased in understandable terms and giving real information. The article started out to confirm this hope, until we met the following:

> Metals fatigue; they tend to crystallize after being subjected to long periods of vibration, and this is extremely important in a fast-moving piece of machinery like an airplane.

In the back of the magazine, we are told that the author of this misstatement about "crystallization," is "a graduate of the Wharton School of Commerce and Finance, has been actively engaged as industrial consultant for 15 years, advising executives on new processes and products and on management questions. In the course of this time he has managed such diversified businesses as the manufacture of machine tools, umbrellas, springs and wallpaper."

We trust the period of service in the manufacture of springs was short, with such a grasp of fatigue phenomena as this article shows. He better stick to wallpaper.

Anyhow, we feel justified in our previous generalization that we, at least, don't have to accept the sociology put forth by authors in *Harpers,* for that may be quite as cock-eyed as is the quoted gem of engineering.—H.W.G.

Priorities

Priorities are nothing new in the metal industry. The early charcoal furnaces in England required so much wood for charcoal that in 1558 a law was passed prohibiting cutting trees for charcoal, save in restricted areas, lest there be no oak left for shipbuilding. This halted the iron industry till the early 17th century when coke began to be used for making iron.—H.W.G.

Another Honor for Metals and Alloys

For the third consecutive time, Metals and Alloys has won an award in the annual competition conducted by *"Industrial Marketing."*

The award was made for the best series of articles or editorials published during the year ended July 31. The series of articles was the one with the title —"Bearing Metals from the Point of View of Strategic Materials"—by H. W. Gillett, H. W. Russell and R. W. Dayton in the Sept., Oct., Nov. and Dec. issues of last year.

The editors and the Reinhold Publishing Corp. acknowledge this honor with grateful satisfaction.—The Editors.

Electric Steel

Among the many remarkable developments in the rearmament program of this country is the expansion in electric steel capacity.

At the end of 1940, the electric steel melting capacity was officially announced as 2,586,320 net tons. This was an increase of 19.5 per cent over the 1,326,788 tons as of Dec. 31, 1936, a sharp expansion in 4 years. In the 15 or 16 years previous to 1936 or from 1920 to 1935 or 1936, the industry's capacity had remained rather static at from 1,250,000 to 1,500,000 tons annually.

Now comes the official report that as of June 30,

(Continued on page 510)

*T*HE PRESENT WAR *is a war of metals. The many metals and their alloys are essential factors. The conflagration which has engulfed almost the whole world could not spread as it has except for metals. Without metals and alloys of many types, airplanes, bombers, tanks, anti-aircraft guns, cannon and rifles could not exist. The nation that does not have these is overwhelmed—the nation that has them in abundance and in predominance is certain of victory.*

The United States may have all or most of these essentials but unless they are turned out at a speed commensurate with the danger involved, victory, or even protection, is not assured. Speed in production of these essentials is one highly important factor in our Defense Program.

William S. Knudsen

Faster Production for Defense

THIS ISSUE is devoted to brief articles which suggest short cuts to faster production for some defense materials. They are written by authorities in four general fields of the metal industries. Hence their manifest value to those metal working industries producing defense materials.

FASTER PRODUCTION

—WROUGHT AND CAST METALS

Blast Furnace Practice

by Ralph H. Sweetser

Consultant in Blast Furnace Practice,
New York

There are two answers to the question—"How can we get more pig iron out of the iron blast furnaces already built and ready to run?"

The first answer is, a greater through-put of *iron-bearing* material when the maximum tonnage of coke is consumed in the furnace in 24 hrs. It is obvious that a furnace should be "driven" at its full capacity in the present emergency demand for output, providing that the quality of the pig iron is maintained.

Starting with the top limit of coke put through the furnace it is essential that the heaviest possible burden of ore and iron-bearing materials should be carried. The new "lean-slag practice" allows this to be done without the usual precaution of "being on the safe side" because of the fear of making occasional casts of high sulphur iron. External desulphurization with soda ash will prevent any high sulphur casts going into the mixer.

In addition to being able to carry the maximum burden of ore with "lean-slag practice," there is no need for as much weight of limestone, with a consequent less weight of slag per ton of pig iron. These apparently small changes in the basicity of the slag do allow a greater through-put of iron-bearing material, but the sulphur in the pig iron made will be above the limits for quality steel, and must be removed by external desulphurization with soda ash. The technique of this practice has advanced gradually since the tests made at the Monessen Plant of the Pittsburgh Steel Co. last year under the auspices of the Blast Furnace and Raw Materials Committee of A.I.M.E.; the feeding of the soda ash into the hot metal is easy and simple and fumes from the reactions are no longer troublesome.

The less amount of extraneous work that the coke has to do the greater will be the through-put of iron-bearing material; "extraneous work for coke" includes the heating and smelting of materials that could be eliminated before charging into the furnace, whether it is water in the air blast; excess gangue in the ore; excess ash in the coke; or even the CO_2 gas in the solid limestone. The elimination of such excess baggage allows that much more through-put of the iron-bearing material for the maximum tonnage of coke.

Another apparently small detail that is gradually being put into standard practice, especially on the larger furnaces in the North, is the shutting of the iron notch without slacking the blast. Such practice eliminates the usual settling of the whole column of stock inside the furnace after each cast and prevents the slow driving and higher blast pressure that follow; this means uninterrupted smelting, and an increase of 3/4 ton of hot metal for each minute saved at an 1,100-ton furnace.

The second answer to the question is the maximum safe utilization of the sensible heat of the hot metal as it flows into the ladles. This means the melting of certain kinds of light scrap in the casting ladles instead of filling it into the furnace through the charging bells. This practice has long been known, but it is likely that it can be increased without any harm to the ladles or to the hot metal. Fast-running "lean-slag" hot metal is favorable to this practice; very low sulphur iron, or slow-running iron, would skull up the ladles if much scrap were used.

Open-Hearth Furnace Output

by Leo F. Reinartz

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Middletown, Ohio

Today steel plant managers are searching every nook and cranny to find ways and means by which to increase the tonnage from open-hearth furnaces.

Usually, when an open-hearth department is operated at full capacity, "bottle necks" and delays seriously interfere with production. To assist in remedying these conditions, the management must know the real facts. It is, therefore, advisable, depending on the size of the shop, to select three or more men—preferably industrial engineers—to study all phases of operations on each of the three turns in 24 hrs. and tabulate their findings. These men will localize the delays so that they may be classed and studied as engineering or operating problems.

In the stockyards, delays may be due to track layout, or inadequate facilities for servicing locomotives with coal and water. Oil electric locomotives, if

properly maintained, give almost 100 per cent service in 24 hrs. Sufficient time and labor should be available to be sure overhead cranes do not cause delays due to poor maintenance.

Enlarging scrap pans, within the limits of charging machine capacities and open-hearth furnace door clearances, is helpful in speeding up shipment of scrap to the furnaces. By spending 50c (or less) per ton on reshearing heavy melting scrap into smaller pieces, the weight in charging pans can be increased 15 to 30 per cent, thus expediting the charging of furnaces. More time and labor spent in loading all kinds of scrap into pans in the stockyard will also decrease charging delays.

The All-Basic Open-Hearth

One of the most outstanding ways that has been suggested for increasing open-hearth ingot tonnage is the development of the all-basic open-hearth furnace. For many years this type of furnace has been in successful operation in Germany, where they have used the Radex basic brick. They claim this design has increased the tons per hour and decreased the operating costs. Campaigns up to 1400 heats have been reported. In England and Australia, where similar designs have been reported to have been adopted, increase in yearly production, averaging from 15 to 25 per cent, has been made possible. Such a change means the complete rebuilding of the furnace, from the slag pockets on up. Basic bricks are used in the entire end construction above the slag pocket arches. From end to end of the furnace all bricks in the roof are basic and are suspended with suitable spring arrangements for the movement of brick when heating and cooling the furnace. In the front and the sloping back wall construction, of course, basic bricks also are used. In such type furnaces the slag deposit is materially reduced. Nevertheless, for best operation, the slag must be removed at frequent short intervals. Higher fusing temperature brick is required in the checker chambers, and provisions are made for blowing the checkers regularly, as well as removing the dust from the chambers several times during the long campaign—preferably through tunnels under the slag pockets. Brick manufacturers say that the American-made basic brick will give results equal to those used in the European practice. We are told that the brick supply, although limited, would be sufficient to take care of a reasonable development in this field.

In those shops where 45 to 55 per cent hot metal is available, scale treatment of the hot metal at the open-hearth shop, for the reduction of silicon to 0.30-0.50 per cent before pouring it into the open-hearth furnace will permit reduction in the limestone charge, and increase the tons per hour of the furnaces. This practice will allow the use of more hot metal in the charge without the use of charge ore or without losing flush-off slag.

Average furnace availability may be increased by careful analysis of repair delays, and paying an extra incentive bonus to masons and laborers to speed up furnace repairs.

Floor expediters in large shops can help decrease congestion and interferences by scheduling hot metal additions and charging operations.

In the pit proper facilities for speeding up the cleaning and preparation of ladles, use of magnets, large grab buckets, and mechanical equipment for removing caps from molds should be available to decrease delays.

Sight should not be lost of the need for job training the personnel in the most efficient methods of work; paying adequate base rates, plus incentive payments for increased efficiency; and instilling into the organization a desire to increase production to help the defense needs of our country. Starting a competitive contest often does more than an increase in pay to spur men on to greater effort.

Open-Hearth Steel Making

by E. L. Ramsey

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Wisconsin Steel Works,
S. Chicago, Ill.

Steel produced by the open-hearth furnace is one of the basic materials required for defense. Every effort is being made to speed up and increase the production of all available open-hearth furnaces and equipment. This rapid expansion of production has had its effect on the raw materials used in steel making. Scrap and hot metal or pig iron are the chief raw materials used by the open-hearth. Because of the big demand for scrap, this material is coming to the open-hearth today in lighter form and not as carefully prepared and classified, and of poorer quality. This adds to the difficulty of getting open-

hearth furnaces properly and quickly charged, especially so when every furnace and piece of equipment is loaded and operated to capacity. The proper preparation, classification, and handling of scrap is essential for fast open-hearth production.

In the basic open-hearth furnace it is customary to charge hot metal from the blast furnace with a silicon content of 0.75 to 1.25 per cent. The trend of recent experiments and practices has been to use hot metal with a lower silicon range. By means of slag control the use of this low silicon metal permits a much lower limestone charge which results in a lower slag volume, a much faster working heat, and a more uniform heat as to temperature and degree of oxidation of slag and bath. Low silicon metal also helps when charged into a furnace that has had a delayed scrap charge; it can be added without the usual foaming slag condition which slows down the working of the heat.

The processes of furnishing low silicon hot metal to the open-hearth are still in their infancy and present problems which have to be solved. It has been produced directly in the blast furnace by the regulation of the composition and volume of the stone charge, and also by the addition of roll scale to the hot metal as it leaves the furnace.

There are several systems of slag control; one is known as the "pancake" test. A sample of slag is poured into a test mold, allowed to cool and its chemical composition can be estimated by the appearances of the test. By the use of these tests, corrections can be made to the slag, keeping the slag volume down to a minimum and maintaining the proper lime-silica ratio. This control results in faster and more uniform heats. It also produces the most favorable conditions for the de-oxidation practice and gives the most consistent recoveries of alloying constituents which are added to the bath.

As many steels for defense are forging grade and subject to machining operations, it is important that these be given special attention as to cleanliness and grain size specifications. This means that the deoxidizers should be added so that the deoxidation reaction products are easily fusible and fluid and can rid themselves from the bath. Additions to the ladle can also be made so as to help reduce objectionable inclusions.

It is necessary during the working of the heat that the open-hearth operator have the cooperation of the laboratory in furnishing rapid and accurate analyses. Final tapping tests should be made under 10 mins.

Along with the increase in demand for steel has come an increase in the percentage of heats that require hot topping. The revamping and expansion of mold yards and equipment is necessary if the molds are to be properly prepared.

For "Faster Production for Defense" the open-hearth should have:

Scrap properly prepared and classified.
Hot metal with lower silicon range.
Slag control.
Proper deoxidation practice.
Fast and accurate service from the laboratory.
Auxiliary equipment sufficient to correspond with the increased production.

Open-Hearth Furnace Control

by C. D. King

Chairman, Open-Hearth Committee,
U. S. Steel Corp. of Delaware, Pittsburgh

The national defense program, requiring an increase in the producing capacity and a speeding up of the production processes for all vital defense materials, has forced the attention of the steel operators upon a more precise control of the open-hearth furnace as a practical means of obtaining maximum production from existing equipment without sacrifice of product quality. Of principal concern to the maintenance of continuously high production rates is the efficient utilization of fuel and of flame temperature. Measurement of the quantities of fuel and air used, correct proportioning of fuel and air entering the furnace, proper application of flame in the combustion zone, and control of temperature in the furnace and regenerative systems, are essential to efficient combustion, fullest utilization of the heat developed in the furnace, and to the attainment of maximum refractory life.

Use of Flowmeters

Furnace control begins with flowmeters for accurately measuring the gas and liquid fuel input. Flowmeters should be of the indicating, recording, and integrating type which permit control of the fuel input rate by the furnace operator and preserve a record of the fuel performance and of fuel consumption for each furnace. Only by this means can the fuel input during the course of a heat be regulated for greatest effectiveness, and the records studied with a view to obtaining the utmost in furnace performance. Liquid fuel flowmeters should be supplemented with steam pressure and fuel temperature recorders to assure constantly efficient atomization at the burners.

Draft Control

Draft control is likewise essential in modern furnace practice. Proper draft regulation minimizes infiltration of air above furnace floor level, maintains a balanced pressure condition within the furnace laboratory, contributes to improved flame direction and combustion, and reduces waste gas volumes thereby improving the useful life of furnace brickwork and checkers. Draft regulation is therefore an indispensable part of open-hearth furnace operation

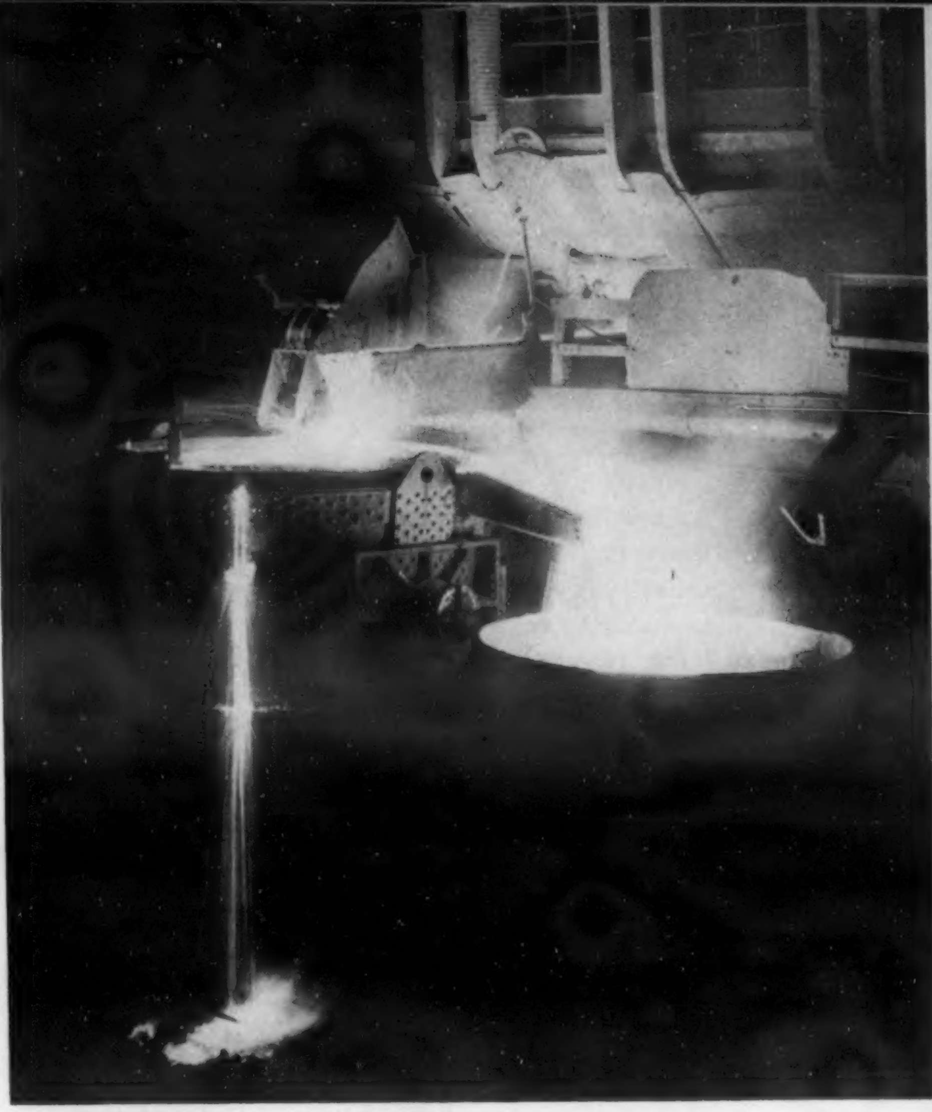
and, since it can be continuously and exactly maintained by automatic equipment, modern furnace practice implies the use of automatic draft regulation.

Forced Air Fans

Where the physical layout is suitable, forced air fans will be found advantageous. The amount of air which can be obtained for proper combustion of fuel on natural draft operated furnaces depends upon the stack effect of checkers and uptakes and the resistance to air flow in various parts of the furnace system. During the melting down stage of a heat, the charge can absorb the maximum heat input without damage to the furnace structure. However, it is during this very period that the temperature in the furnace system and therefore also its stack effect is at its lowest, and accordingly the amount of fuel which can be properly burned is limited to the reduced amount of air which can be supplied under these conditions. As furnaces become older, the resistance in flues and regenerators increases and consequently less air is available on such furnaces than on new units. The use of forced air fans makes the furnace independent of either temperature conditions or frictional resistance so that the air required at all times can be provided according to the quantity of fuel used. Forced air equipment with provision for measuring the air delivered to the furnace assures a correct air input by regulation of the fuel-air ratio. Automatic fuel-air proportioning may be used or the ratio may be controlled manually. A combination of measured forced air and automatic draft control offers an effective means for providing the correct furnace atmosphere and efficient flame characteristics for rapid melting and refining. Proper characteristics of flame during different stages of the furnace cycle are of fundamental importance to fast production rates and are obtained by the fuel, air and draft control equipment when combined with the experienced furnace operator's ability to judge correctly his furnace conditions.

Measuring and Recording Temperatures

The measurement and recording of temperatures in various parts of the furnace system is essential to proper regeneration and the preservation of refractories. Multiple recording pyrometers with thermocouples (or radiation elements) located in the checker chambers and flues permit either automatic or manual reversing of the furnace air and gas valves at the optimum regenerative temperatures for efficient recovery of heat from the waste gases. Careful control of reversal time in conjunction with temperature assures the correct preheating of combustion air, promoting maximum heat input to the furnace with simultaneous protection against burning of the checker brick. The actual reversal should be accomplished as rapidly as possible and means are now available for quick reversal and proper sequence of the steps



required. A difference of as little as 5 seconds per reversal is equivalent to 450 tons or 3 heats per month at a 10 furnace shop tapping 150-ton heats.

Roof temperature control offers a means for maximum fuel input and production by safeguarding the roof refractories. The control can be arranged so as to limit the maximum roof temperature desired by automatically reducing the fuel in increments to accomplish the necessary adjustment. The control can also be used as a guide to the first helper, permitting him to make the adjustments manually. Roof temperature control may be found useful in supplementing the skill of first helpers toward attaining reasonable roof life and assuring maximum fuel input and production rates.

Increased Production

Furnaces equipped in the manner described should show a marked increase in production rate with a corresponding decrease in fuel consumption compared with similar furnaces operated without such equipment. To obtain the maximum benefit from such control instruments and equipment, assuming the controls are of the proper type and correctly installed, three essential principles should be followed:

1. The furnace system should be maintained in a manner to reduce radiation losses and air leakage to a minimum.
2. The equipment should be properly serviced and maintained to assure a high degree of accuracy and reliability, thereby commanding the confidence of the operators and their reliance upon unfailing performance.
3. First helpers should be instructed and supervised in the proper use of the provided instruments.

Bessemer Steels

by H. W. Graham

Director of Metallurgical Research,
Jones & Laughlin Steel Corp., Pittsburgh

From the standpoint of rapidity of the progress of metallurgical reaction, the Bessemer process has today no competitor in the American iron and steel industry. A converter will produce 25 tons of steel in about 12 mins., or smaller blows in a few minutes less. Nowhere in the steel making industry is there comparable speed or concentration of production per unit of facility. In today's pressing demand for increased steel production, no one can accuse the Bessemer process of being a laggard. In fact the limitations of Bessemer production are before or after, but not in, the converting department. The Bessemer plants of the United States are not now working at full converting capacity. Either iron is not available in sufficient quantity or blooming capacity is limited or the volume of orders is restricted.

Some upward revision of nominal rated capacity at the beginning of 1941 gives the Bessemer capacity of the United States currently as slightly under 7,000,000 net tons. Production for the first half of the year was at the rate of 75 per cent thus predicting a total Bessemer tonnage for 1941 of about 5,250,000 tons. This will be the largest tonnage produced by the Bessemer process since 1930, when 5,640,000 tons of Bessemer steel were made.

But the steel industry, because of the falling off of Bessemer demand in the past two decades, more and more discounted the capacity of its converters, whereas as other facilities were generally held at about their true level of productive ability. It must be accepted that the true Bessemer capacity is considerably more than the nominal figure of 7,000,000 tons per year. In fact, if pig iron were available and if the ingots made could be bloomed for orders that were available, existing converters in the United States would probably be capable of making some 10,000,000 or 12,000,000 tons of Bessemer steel.

Therefore in the present emergency the problem of increasing the production of Bessemer steel is not primarily concerned with the converting department but rather it rests in seeing that orders are at hand and that iron is available in adequate quantity. In the few instances where the converting department is really busy, blowing time can be reduced by iron ore additions and by other measures already known to the operations; but the Bessemer method is so rapid inherently that speed-up measures in that department are of less importance and interest than they are in other phases of iron and steel manufacture.

The converting department is also contributing greatly to increased open-hearth tonnage in recent months by providing more blown metal for the duplex production of basic ingots. Duplex tonnages dropped off some in the period of 1938 to 1940 due to adjustments in method by some of the larger producers, but the pressure of present demand is tending to reverse this trend. It may be confidently expected that the 1941 duplex tonnage will considerably exceed the 1940 figure of 2,200,000 tons.

It is interesting to note that the Bessemer process, as well as being a rapid steel making method, yields a product that contributes to rapidity of fabrication by machining and other processing. Considered from the angle of speed alone, the Bessemer process stands at the top of the list.

Electric Furnace Top Charging

by G. V. Luerssen

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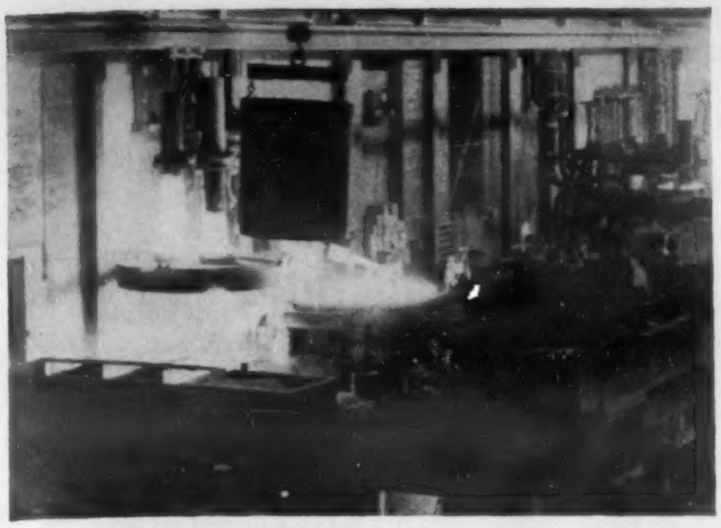
It is hardly necessary to call attention to the urgency of increasing the output of available arc steel melting equipment in the United States. It is in order however, to point out that the arc furnace is one of outstanding cases in the steel industry of large capital investment in equipment, and consequently the advantage of getting out every possible pound per unit of time evidences itself not only in lower operating costs but also in decreased necessity



for additional specialized equipment. It is likewise in order to point out that simply a step-up in ingot production will not do. The final goal must be to increase the production of acceptable material, which is another way of saying that any devices or practices used to increase production must function without a corresponding decrease in quality.

Some such devices used successfully are high power input, faster methods of control analysis, preheating of heavy additions such as in the manufacture of some stainless steels, and carefully designed molds and hot tops to insure maximum yield from ingot to finished product.

One of the outstanding methods of increasing production, and one which has the added advantage of indirectly assisting in maintaining quality, is that of top charging. This involves the use of a furnace in which the entire roof, electrode and mast assembly can be removed for charging, either by lifting off entirely or lifting and swinging on a pivot. The charge is loaded in a suitable bucket which is lowered into the furnace by crane and unloaded through the bottom.

As a specific example of this practice, a swing-roof type Swindell furnace is being used having a shell diameter of 11 ft., and an operating capacity of approximately 10 tons. The roof together with the masts carrying the electrodes are integrally mounted on a raising and swinging device between the shell and the winch motors, consisting of a hydraulic ram for lifting and a rack and pinion for rotating.

The bucket is built of $\frac{1}{2}$ in. welded plate, cylindrical in shape, 8 ft. high by 6 ft. 8 in. in diameter, with an orange peel bottom tied in the center with heavy hemp rope. The bucket is loaded in advance by a magnet, preferably with heavy scrap on the bottom and the lighter scrap on top.

After bottom and banks have been patched up, the bucket is brought up close to the furnace at the proper level, the roof is swung off, the bucket spotted over the furnace and lowered so that its bottom is level with the top of the shell. The hemp rope is of such thickness as to burn through in about one minute at which time the orange peel opens and releases the charge. The bucket is then raised, the roof swung back into position, and power switched on immediately. The entire operation of removing roof, charging, and replacing the roof consumes about 3 mins.

The advantages of this practice are first, a saving in time of charging, which in the case of hand charging amounts to 25 to 35 mins. per heat; second, saving in charging labor; third, elimination of much of the heat loss during charging; and fourth, better distribution of the charge in the furnace, the latter two advantages showing up in a shorter and more uniform melt down. A further advantage lies in the fact that with this practice it is possible to charge more light scrap than in the door charging methods, since it allows piling the charge higher in the furnace. In using this practice, it is preferable to so select the scrap that the entire charge can be introduced from one bucket. While the practice described applies to a 10-ton furnace, the swing type charging practice has been used on furnaces up to 18 ft. shell diameter and would undoubtedly be applicable to smaller furnaces with some modifications.

One of the obvious problems arising in the use of this practice is that of roof refractories. This has been largely solved by the use of high alumina fire brick to replace the silica brick several courses from the skew, and in some cases by the use of a complete roof of high refractory fire brick.

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By installing recuperators on industrial furnaces *[?]ter production can be attained. In one case, where 600 tons of steel per week were produced formerly, now 900 tons per week can be obtained with a remodelled furnace and recuperator. The furnace originally was built with regenerative chambers with the flame reversing periodically. The recuperator eliminated the regenerators and flame reversals.*

—Fitch Recuperator Co.

★ ★ ★

Many foundrymen can relieve the shortage in nickel and assure themselves of ample supplies of a nickel alloy by changing from copper-nickel 50/50 to a 25 per cent alloy of nickel and copper. While it would be necessary to use 2 lbs. for every 1 lb. previously used, it would cost no more for the nickel or copper contents. In one case, you get a $\frac{1}{2}$ lb. of each element and in the other case, you get a $\frac{1}{2}$ lb. of nickel and $1\frac{1}{2}$ lbs. of copper.

—Niagara Falls Smelting & Refining Corp.

Making Steel Castings

by John Howe Hall

Consulting Metallurgical Engineer,
Chestnut Hill, Pa.

Probably there is no specific practice that, if generally adopted, would result in faster performance or greater production of steel castings, than redesigning in such a way as to make the finished article by a combination of casting and welding. This is particularly true of medium and heavy parts, such for instance as many ship castings. In these, light and heavy portions are frequently combined in such a way as to result in a large number of intersections that constitute "hot-spots." By this, the foundryman means a portion of a casting that is necessarily of greater volume per unit of surface than the adjacent parts, and therefore solidifies later than the thinner portions of the piece. The result is often either a shrinkage cavity, a tear, or both.

To prevent the formation of such defective spots, pattern alterations are only partially successful, and much time has to be spent in the foundry, placing chills, cutting brackets, molding blind heads, and so forth. Were this the only extra expenditure of time involved, the case would be bad enough. Quite often, however, the molders' efforts do not suffice to prevent the formation of some defects, which are found by visual and radiographic inspection.

The defective portion then has to be chipped away until only sound metal remains, the resulting cavity is repaired by welding, and in important castings the weld is reradiographed to be certain it is sound. If a defective weld is discovered, all or part of the weld metal has to be chipped out and the job rewelded and reradiographed. There is no particular doubt that, in hundreds of cases, as strong a job would be secured if the piece were designed in the first place to combine one or more castings, with plate or structural steel, welded together at the intersections. Sometimes so much of an integral casting is chipped away before welding that the intersection consists largely of weld metal, and can not possibly be stronger than a welded joint between cast and rolled metal, or between casting and casting. If designed in this manner, the time spent in preliminary radiographing and chipping out defective metal is saved, to say nothing of the time spent by the molder and mold-closer in placing chills, cutting brackets, etc.

In concerns which both design and make the part, this combination of the arts of the founder and the welder has already made enormous strides. It remains for the simon-pure steel foundries to follow in the footsteps of their more fortunate brethren—a step, of course, that can only be taken with the full co-operation of their customers. The latter would do well to send their engineers and designers to study the methods of the progressive machinery builders, who are already so successfully pointing the way.

Gray Iron Foundry Practice

by James T. MacKenzie

Chief Metallurgist,
American Cast Iron Pipe Co.,
Birmingham, Ala.

The use of molding machines reduces manual labor with consequent reduction of fatigue and allows rapid training of unskilled men as machine operators, thus easing shortage of skilled molders. Mechanical handling of sand insures uniform supply of well mixed and well tempered sand without necessity of skilled men and with practically no hard labor. This has an important effect in the reduction of losses and makes for easy cleaning. Conveyors handle molds from machines to casting station and on to shake-out. Iron is mechanically handled too, thus reducing fatigue.

Core blowing machines are being used more and more, even for larger sizes of cores for heavy production schedules. Use of continuous automatically controlled core ovens gives better cores in a continuous and uniform flow. Increased attention is given to dust removal and atmospheric control, thus increasing comfort and efficiency of men.

Castings are being used to replace forgings, saving considerable weight and a great deal of machining. Many parts now being forged can be cast practically to size.

Pneumatic hammers for chipping and portable grinders have helped a great deal to cut time in the cleaning sheds and the hydraulic cleaning methods have shown pronounced benefits in removing cores while at the same time making possible the recovery of much core sand in excellent condition for use.

Storage facilities for raw materials in car-load lots with lift truck deliveries help to speed up production. Core rooms and cleaning rooms are working night shifts to keep up with production and the introduction of sand handling systems has enabled shops to go on extra hours or even to double shift.

Much ingenuity is being shown in rigging and utilization of floor space. Molds are stacked and overhead heaters are used for drying. Flasks are being standardized thus speeding up production in slip and snap flasks. There is thus less equipment to handle, such as bottom boards, pouring jackets, etc., and this makes less delay on the part of the molder waiting for such equipment.

With so much work to be done, no foundry should accept work which is not suitable for its particular molding equipment, or requires special metal which it is not equipped to produce or with which its personnel is not familiar. A green sand foundry should not undertake work which should be made in dry sand, and it is not economical to make in dry sand castings that can be made perfectly well in green sand. Again, alloy cast irons in small tonnages can not be made economically, due to the trouble of getting the value of the alloys in the returns—gates, sprues, and scrap. Alloy castings should be concentrated, as far as possible, from a conservation standpoint as much as from the skill and experience angle. Likewise, heavy castings are out of place in a light shop and vice versa.

Cupola Practice

by Donald J. Reese

Development and Research Div., International Nickel Co., New York

A portion of our increased hourly and total tonnages may be attained by narrowing down the variations in practice which we have put up with in the past.

Demand that your coke supplier maintain the quality of his product, then aid him in meeting his commitments by applying all the means of fuel conservation available to you. Buy a "sized" coke of 1/12 the cupola diameter in size. Weigh the coke charge accurately. Use 10 or 9 or 8 lbs. of coke per sq. ft. of cupola area and not 20 or 25 or 30 lbs. per sq. ft. A proper height for the coke bed in inches of coke above the main tuyeres is $10.5 \times \sqrt{P} + 6$. P is wind box pressure in ounces, so with 16-oz. pressure, the bed height should be 48 in. Don't forget that a successful day's run begins with a properly "burned in" coke bed. Hot metal on the first tap is dependent on sufficient soaking time to preheat the sand bottom and well refractories. An hour's time between light up and wind on is "too" little soaking time. Excellent results are obtained when the bed soaks as much as 5 or 6 hrs.

Avoid wasting this high quality metallurgical fuel in shop salamanders, to preheat ladles, to vent cores, to bake cores, etc.

With 30, 50 and 70 per cent steel in the cupola charge, the carbon levels in the iron should be 3.05, 2.70 and 2.35 per cent, respectively. The main reason for using steel in the cupola charge is to attain desired carbon levels though it also helps to attain high metal temperatures (above 2800 deg. F.) and lowers the phosphorus content in the iron. Steel scrap is deficient in silicon, and each ton of steel used unnecessarily, requires about 40 lbs. of silicon to make the product gray and machinable. The supply of both steel scrap and silicon needs to be conserved to the best of our ability.

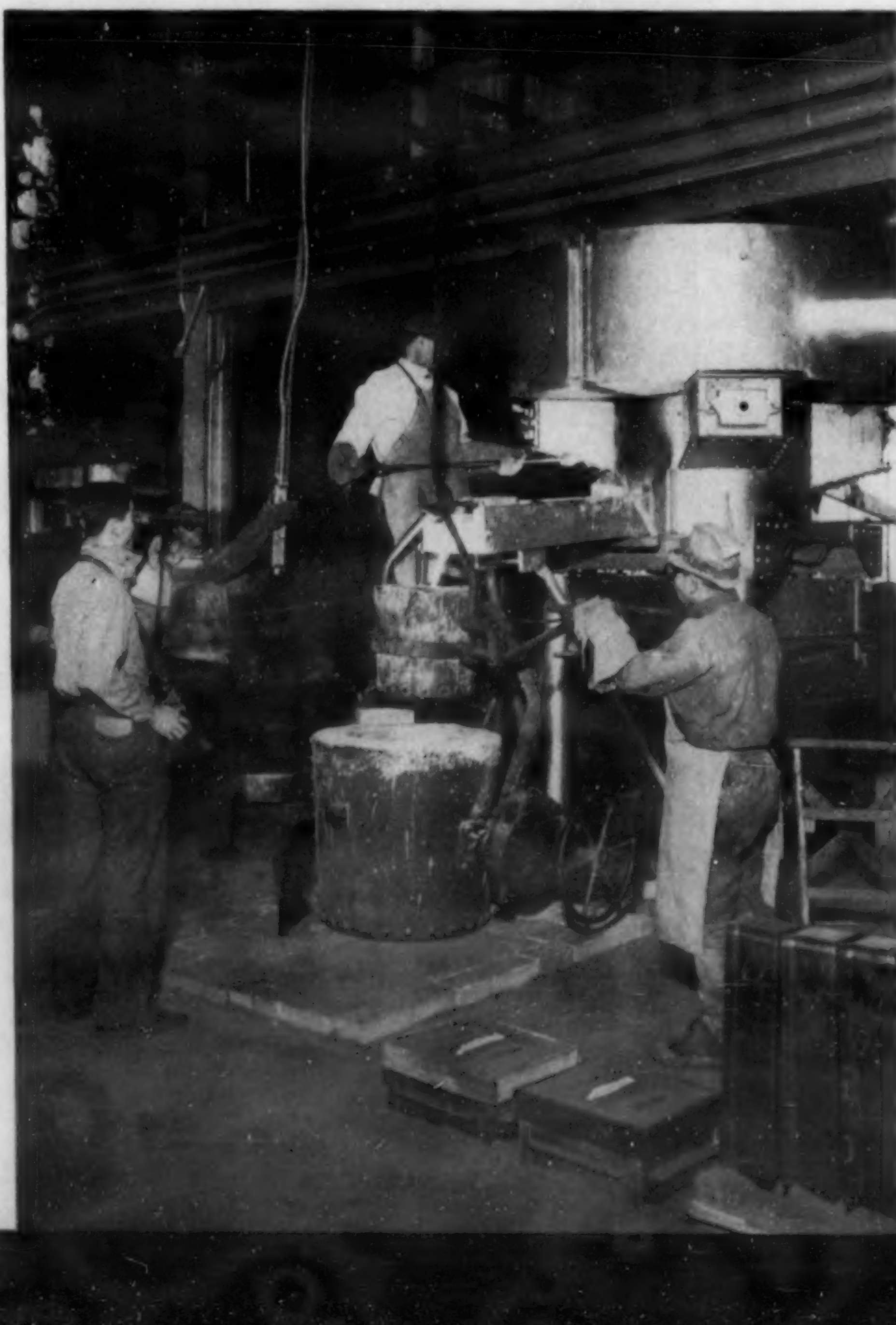
Plan your metal distribution so that only the right amount of metal goes to the pouring floor and that ladles are completely emptied before receiving a new supply of metal. See that metal reaches the pouring floor in the least possible time after it is tapped from the cupola. It is good practice to weigh this metal if it is at all possible to do so.

Cupolas work best when the melting rate is above 1500 lbs. per sq. ft. per hr. and up to 2250 lbs. Successful operation becomes increasingly difficult as the melting rate approaches 750 lbs. per sq. ft. per hour. If your cupola is melting slower than 1500 lbs. per sq. ft. per hr., speed it up by using more air, or if you can't handle the higher hourly output, line down to a smaller diameter.

Plug up leaks in the air circuit between the blower and the melting zone of the cupola and don't overlook the large air loss through an oversized slag hole. Air losses may exceed 20 per cent of the air delivered by the blower. If you have a fan-type blower, don't cover the intake with a screen finer than 1-in. mesh.

The charging gang has the important job of controlling the chemistry of iron. All materials going into the cupola must be weighed accurately and as the charge was calculated.

Don't waste your time worrying about tuyere area, oxidized metal, cupola pressure, etc. Have courage



to use materials that you formerly considered unsatisfactory for a cupola material provided the chemistry and linear dimensions are satisfactory; 30 per cent of the cupola diameter is a satisfactory linear dimension.

Remember that the cupola is a high speed melting unit and to evaluate its performance in pounds of iron melted per minute or per second is a measuring stick leading to better knowledge of its performance. Do these things:

1. Size materials to best suit your cupola.
2. Accurately weigh all ingoing materials, and, if possible, outgoing iron.
3. Conserve fuel, silicon and steel scrap.
4. See that coke bed is burned through properly and that it soaks more than 2 hrs.
5. Melt 1500 lbs. or more per sq. ft. per hr.
6. Plug up all air leaks, including the unnecessary amount through the slag hole.
7. Expedite metal handling and do not store more than a 12 to 15-min. supply in reservoir ladles.
8. Preheat ladles to a white heat if at all possible.
9. Improve yield of good castings from total iron melted by eliminating need for pigging cold metal.

Malleable Iron Castings

by H. A. Schwartz

Manager of Research,
National Malleable and Steel Castings Co.,
Cleveland.

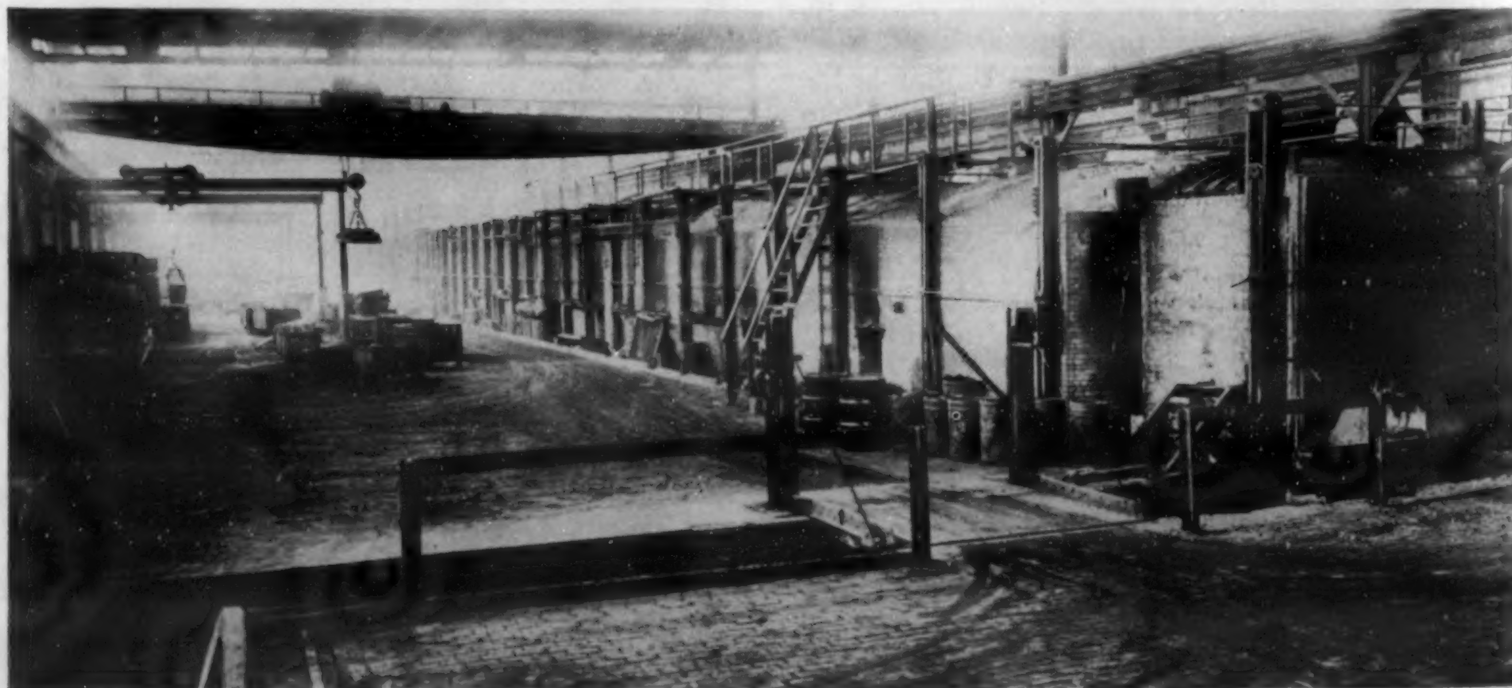
Since even those malleable plants which confine themselves to one shift must still operate their annealing departments on a 24-hr. basis, the problem of increase in malleable iron production can not ordinarily be solved merely by putting on one or two additional shifts of molders.

An increased production from a given plant thus usually involves some study of increasing the output of the annealing department. Two types of solution are looked for: Either to make a more annealable iron, or adopt a shorter annealing cycle. Both expedients are subject to definite limitations. An increase in annealing ability by changes of chemical composition finally is limited when compositions are reached in which there is danger of primary graphitization. These limitations are already rather well understood, but quite obviously anything which is done to insure constancy of chemical composition makes it possible to have the average analysis approach the danger line more closely without fear that an unexpected variation will produce unusable material. Increased attention to analytical supervision and control is thus indicated.

In an attempt to shorten the annealing cycle, the operator is limited by certain indispensable considerations. Annealing is accomplished by holding the product a given time, at a given high temperature, the time decreasing as the temperature increases. Unfortunately the physical properties of the product decrease as the annealing temperature increases. Also the time which can be saved by raising this temperature from any ordinarily used value to the maximum permissible value is, at best, only a matter of some hours.

Second stage graphitization is best accomplished by cooling at the correct rate, through a temperature interval of perhaps 50 deg. F. embracing the critical range. Above and below this critical range, cooling rates may be as fast as any commercial mechanism will permit. It is actually advantageous to withdraw the stock from the furnace at 1100 deg. F. or 1200 deg. F. if that is mechanically possible.

The execution of the minimum annealing cycle depends primarily upon the ability to have all parts of the charge change temperature alike and at that rate best suited to the metallurgical purpose. This is



largely a matter of furnace design and operation.

The writer has seen many instances where, in order to get more material into a furnace, the size of pot was increased, or the pots set closer together, with the effect of minimizing the rate at which heat could be transmitted into the more inaccessible portions of the charge. Such a practice can easily waste more time in slowing up heating and cooling than is gained by the equivalent of a larger amount of castings handled. This condition is particularly critical during the cooling interval if there are great temperature differences in various portions of the same furnace, then the time required in order that every portion of the furnace may cool at the preferred rate will become so great as to largely retard the output.

From the annealing cycle viewpoint, therefore, attention should be directed to uniformity of temperature in a given unit, not overlooking the limitations on the rate at which heat can be transferred from the surface to the center of the pots used.

Copper Base Castings

by John W. Bolton

Chief Metallurgist,
The Lunkenheimer Co.,
Cincinnati

In the casting field "Faster Production for Defense" begins with getting good sound uniform castings. This is equally true whether the castings be copper base alloys, specifically bronzes, as discussed in this article or brasses or steel, or cast iron or light metal alloys.

Low foundry losses and minimum machine shop rejection and troubles, coupled with structures suitable for rapid machining and for the services to be encountered are mandatory if really fast production is to be attained. Castings troubles represent losses in melting room, in molding, in cleaning, in machining, and in inspection. Actual loss in efficiency is several times the percentage loss of castings. There are lost not only man hours, but also materials, machine capacity and the like—and a heavy drain on the supervising staff occurs. Bad castings in the machine shop often mean not only man hour losses, but also often make it impossible to set suitable high machining rates—in production work the rate must be set on the least favorable portion, not on the average or on the optimum cutting portions. Uniformity is very essential.

It is not a purpose of this article to discuss materials handling, sand conditioning, molding methods, or machine shop practices. It is preferred to start with the melting process, the foundation or starting point.

Importance of Furnace Atmospheres

Furnace atmospheres are highly important. Years ago there was a great deal of talk about the evils of "oxidizing" atmospheres. Researches within the last 15 yrs. have shown conclusively that "oxidizing" atmospheres are not often responsible for defective bronze castings, in fact slightly oxidizing conditions may be desirable for some purposes.

As has been shown by the writer and others the usual cause of intercrystalline porosity is what may be termed incipient shrinkage, and it has been shown that presence of excess reducing gases, particularly carbon monoxide and hydrogen in the furnace atmospheres, are potent factors in aggravating and promoting spongy, unsound castings. Out of the welter of contradictory opinions and inconclusive experiments it is definitely clear that carbon monoxide (in absence of hydrogen) can promote unsoundness in bronzes and that hydrogen definitely is dangerous in making copper castings. It is probable that hydrogen may be an offender in bronzes also.

A first step in speed and efficiency is definite and accurate control of furnace atmospheres. One gas analysis is worth a thousand melters' opinions. By regular use of an Orsat apparatus and suitable (preferably constant automatic) burner regulation positive control can be effected in fuel burning furnaces. In electric furnaces atmospheric control also can be definitely effected. Excesses of reducing gases can be avoided or eliminated. For most purposes on ordinary bronzes a maximum of carbon dioxide and a slight excess of oxygen is desirable. In fuel-fired furnaces such atmospheres offer added advantages in most rapid melting and maximum fuel economy. In view of the obvious advantages in better castings, low losses, speed, and fuel economy it is surprising that many foundries shy at the simple technical control and regulation needed.

Temperature Control

A great deal has been written about temperature control, particularly control of pouring temperatures. With proper furnace atmosphere control, ranges of permissible pouring temperatures are considerably widened. Pouring temperatures depend on the size and design of castings and on the ability of the sand to withstand the action of the metal. In general higher temperatures promote better feeding, lower temperatures help avoid sand troubles and mask to a degree improper furnace conditions. Actual melting process temperature, in the furnace before pouring, is in many ways as significant as pouring temperatures. Overheating is detrimental, and regular pyrometric control of furnace melting temperatures desirable.

Gating and riser practices should be generous. A high yield (on melt) is false economy if unsound castings are a result.

Pouring hot metal onto charcoal is bad practice and much metal has been gassed from this cause.

Beside general porosity, incipient shrinkage, fine pinholes may at times be found, especially on machined surfaces. Some may be readily visible, usually round in cross section; some may be very fine, barely visible under a 5 X magnifying glass. This trouble often is due to low permeability in molding sand, and related causes. Some alloys are more susceptible to it than others.

There are many types of defects other than the two mentioned, but in general foundrymen and metallurgists understand their symptoms and control rather well.

Special Alloys

Certain of the special alloys, silicon bronzes and brasses for example, require distinctly different practices than are required for the tin, tin-zinc, and tin-zinc-lead bronzes. For the tin and related bronzes, phosphorus added to residual amounts of under about 0.02 per cent is an efficient deoxidizer and cleanser. The other copper base alloys often require special additions and careful research and some experience is needed to handle them to best advantage. With properly worked out and standardized practices they can be made with very little foundry trouble.

In the alloys containing tin, presence of the alpha-delta eutectoid is a definite deterrent to maximum machinability. The presence of phosphorus in considerable amounts increases the amount of microscopic hard spots, as does iron when this gets high. The addition of lead to these alloys very markedly promotes machinability. Up to about 1.5 to 2.0 per cent the increase in machinability is very marked, beyond that range the increment hardly increases in proportion to the percentage. For pressure work some of these alloys are permitted at temperatures of 550 deg. F., and below that for most of them. Careful studies have shown that there is no appreciable difference in creep strength or loss of ductility (embrittlement). Specifications not permitting lead thus are unduly restrictive and such specifications slow down machining very materially.

Concluding, the starting point for faster production of bronze castings for defense lies in foundry practice, low foundry and machine shop losses, good and uniform castings. To attain these ends regular technical control is very essential, and especially so as preventative medicine. Methods of gas analysis, pyrometry, sand testing and the like are needed in addition to chemical analyses, physical tests and some microscopy. Low losses, serviceable product, ready machinability, these are sound foundations. Control of furnace atmospheres by actual gas analyses is urged as a desirable specific practice too infrequently employed.

Light Metal Castings

by Norman E. Woldman

Chief Metallurgical Engineer,
Eclipse Aviation, Div. Bendix Aviation Corp.,
Bendix, N. J.

The present national defense program for aircraft construction has given great impetus to the light metal foundries in the production of magnesium and aluminum alloy castings. The apparent shortage of pure magnesium and aluminum metals is rapidly being corrected by federal sponsored construction of new plants for the extraction of these metals from their ores and minerals.

The aircraft industry has taken the lead in the demand for light alloy castings of these two metals. The aircraft engine, the airplane body and the aircraft accessories demand light weight alloys as far as possible.

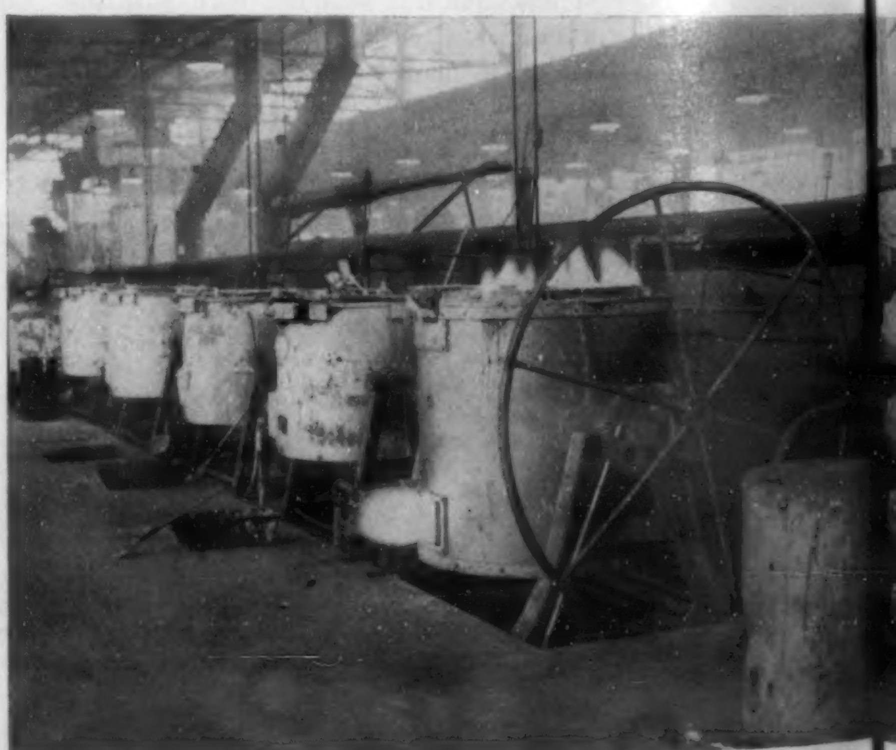
Light metal castings are produced in three different types, namely:

Sand castings
Permanent or semi-permanent mold castings
Die castings

The type selected is determined by the design, application and production quantity. When cores are not too complicated, permanent mold castings are replacing sand castings since permanent mold castings can be made faster and have less stock to machine off.

To meet the heavy demand of the aircraft industry for light castings, the foundries have speeded up production by the installation of continuous conveyor systems wherever feasible.

Pot type aluminum alloy melting furnaces



In the core room, continuous conveyor type core baking ovens have replaced or supplemented the batch type core ovens. The continuous conveyor moves slowly alongside the core workers' work benches, then into and through the baking oven, and finally out through the exit end to the core assembly floor and back to the core workers' work benches. The production of the sand molds in the flasks has been greatly increased by the use of mechanical molding machines to replace hand molding.

Magnesium and aluminum alloy castings are heat treated either by a solution treatment only or by a solution treatment plus aging treatment. The batch type furnaces produce a bottleneck in the production output owing to the long soaking periods necessary for proper heat treatment. They are therefore being replaced in the larger foundries with continuous type heat-treating furnaces.

For the heat treatment of aluminum alloys two separate continuous furnaces are required, one for the solution treatment and the other for the aging treatment. The baskets of castings emerging from the solution treatment furnace are quenched in hot water and are then conveyed into the continuous aging furnace. For the heat treatment of magnesium alloys, since no water quenching is necessary, one continuous furnace divided into several compartments is required. These compartments consist in sequence as follows: Preheating chamber, high temperature heating chamber, high temperature soaking chamber, forced air cooling chamber and low temperature aging chamber. The aluminum or magnesium heat treatment furnaces may be either the pusher roller-hearth type or the rail-buggy type.

Finish machined aluminum alloy castings are subjected to an electrolytic anodizing treatment to increase the resistance to corrosion. The two methods used are the chromic acid process and the sulphuric acid process. Since the chromic acid process takes about 45 to 60 min. and the sulphuric acid process takes about 30 mins., the latter has been replacing the former to expedite production.

Magnesium alloy P & W engine nose pieces

★ ★ ★

The heat-treatment of castings of austenitic 18-8 chromium-nickel steel to impart full resistance to intergranular corrosion, can be eliminated by the addition of a small percentage of ferro columbium. The good mechanical properties of the steel are still retained.

—Electro Metallurgical Co.

★ ★ ★

By using a fast-setting magnesite hearth refractory in place of conventional magnesite-and-slag construction, for resurfacing, new construction and general maintenance of open-hearth furnaces, valuable time can be saved. This quick-setting refractory can be installed in half the time required to burn in a conventional magnesite-and-slag hearth.

—Basic Refractories, Inc.

★ ★ ★

Steel Mill Heating Furnaces

by M. H. Mawhinney

Consulting Engineer,
Salem, Ohio

Furnaces for steel heating fall into two general classifications: Those used in conjunction with forming machinery, and those for metallurgical treatment.

In operations involving the first class of furnaces, including rolling and forging, the common notation on mill delay sheets is "down for heat." Such a notation not only specifies a certain amount of lost time in production from the machinery served by the furnace or furnaces, but it also indicates a forcing of the furnaces. Forcing furnaces to the limit of their capacity usually means uneven heating through the section of the heated pieces, overheating, and other conditions which frequently cause loss of production in subsequent operations.

In spite of these results from inadequate furnace equipment, it is unusual for furnace capacity to be increased with mill improvements in existing installations, and on new installations necessitated by defense expansion the tendency is observed to be too optimistic on furnace capacity.

To avoid this loss of production from limited furnace capacity, the *average* hourly production required should be used as a basis for the computation of furnace hearth area. Average production is the

tons per average turn divided by 8 hrs., or an equivalent figure. On the basis of this average production, the rule for hearth area required is determined by the following permissible rates of heating per square foot of furnace hearth:

Batch type furnaces—25-50 lbs. of steel per sq. ft. of hearth per hr.

Continuous furnaces—40-60 lbs. of steel per sq. ft. of hearth per hr.

In the case of batch furnaces, the low figure of 25 lbs. per sq. ft. per hr. applies to the heating of billets where the furnace is charged and discharged one door at a time and with a single layer of pieces on the hearth, while the maximum usual rate of 40 lbs. per sq. ft. per hr. applies to small forgings where it is possible to keep the hearth covered. Continuous furnace production varies with the uniformity of heating required. Some forging operations can be pushed harder than is possible with the heating for rolling of alloy steel billets for example.

Furnaces for annealing are a common restricting factor in defense effort in the steel plants. Here, the average rate of production for full annealing (above the critical and followed by furnace cooling) is about 5 lbs. per sq. ft. of furnace hearth per hr., but furnaces with a rate of 2 lbs. per sq. ft. per hr. are commonly found. This does not seem to be a great difference at first glance, but means a monthly production of only 40 per cent of the average. The usual causes are non-uniform firing which necessitates waiting for the slowest part of the charge, and slow handling between charges on account of obsolete equipment.

Application of recirculation (forced convection) heating for temperatures under 1300 deg. F., and particularly under 1000 deg. F., have been found to increase production, and bottom firing will work wonders on many of the old furnaces. Handling cranes, spreaders, motor driven cars on car furnaces, and other modern devices will do much to increase production by reducing delays between charges.

In conclusion, it is the opinion of the author that a sufficient amount of hearth area is the most common cure for production difficulties in furnaces used for heating for forming operations, while design and auxiliary equipment are indicated in most cases to improve production from furnaces for annealing operations.

Rolling Mills and Auxiliaries

by F. H. Allison, Jr.

Metallurgist,
United Eng. & Fdy. Co.,
Pittsburgh

The amazing tonnages of finished metal required for the rearmament program have naturally resulted in throwing a burden on the builders of rolling mills and auxiliary equipment, because the rolling mills are industry's prime machine tools in the forming of metals. Continuous mills for sheet and strip are being built to meet the demand for aluminum, brass, and copper products for airplanes, cartridge cases, and the like. Increases in demand for small round stock have resulted in the erection of more continuous rod mills. Shells require forging blanks of semi-finished rolled steel, but the present merchant mills are adequate to supply this stock with no radical change in design or practice.

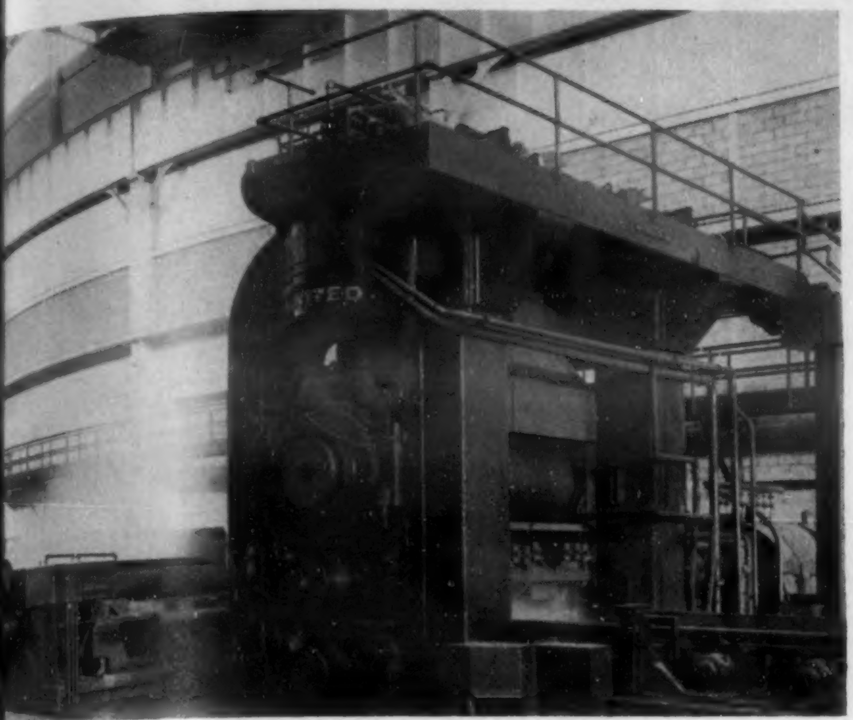
Perhaps the largest demand is for flat rolled products such as strip, sheet, and plate. Tin plate is required for containers, gas masks, and general army utility work; galvanized sheet in large quantities is used in the buildings of the army camps; and cold rolled sheet is necessary for fabrication of army trucks and service cars. Possibly the largest unfilled requirements are for all thickness of steel plate. Large tonnages of plate will be required to construct the multitudes of tanks and ships that are on order. Ships require quantities of $\frac{1}{4}$ to $\frac{1}{2}$-in. plate for light construction; destroyers and submarines demand $\frac{3}{8}$ to $\frac{3}{4}$-in. plate; and general ship building takes a large amount of $\frac{3}{4}$ to 2-in. plate. It is fairly evident from the size of the tank and shipbuilding program that the steel mills must get prepared to produce large quantities of plate.

Plate is usually produced on three-high mills, two-high mills, reversing two-high mills, and tandem two-high mills, while various combinations of three-high and two-high mills in tandem for roughing and finishing have also been used. Such mills as these produce plate 3/16-in. or more in thickness and the product requires shearing to size on all four sides. The Universal plate mills which have been in use provide plate with rolled edges so that shearing is necessary only on the two ends. This is accomplished in Universal mills by two sets of vertical rolls on either side of the main horizontal rolls, the vertical rolls edging the plate to size as it passes through the mill.

Stepping up the production of plate offers the greatest single possibility for the increase of rolled products for armament production. This is being done by converting the 4-high continuous strip mills into plate mills. These mills were originally intended for rolling thin strip and sheet used as auto body stock and similar products, and they are fast,

Billet heating furnaces, batch type. (Courtesy: Penn. Industrial Engineers, Pittsburgh, Pa.)

Continuous 100-in. plate mill



accurate, and produce at low cost. The 4-high continuous mills can be adapted to plate rolling by taking lighter drafts and passing the metal through some of the stands with no reduction so that thicker gauges result. By suitable arrangements, plates of all thickness can be produced and for rolling light sheared plates these mills may be considered the last word. The product is excellent from the standpoint of accuracy, uniformity of gage, and surface. The continuous operation also makes the speed of production a maximum. In this country there are approximately 20 of these continuous 4-high mills, which is more than twice as many in all the other countries of the world.

The conversion of the 4-high continuous mill to the rolling of thicker gages does not require much change in the mill itself; but since the mills were originally built to furnish thinner stock, a number of changes must be made in the auxiliary layouts and handling equipment. The thicker gages require less actual rolling time in the mill and are therefore run out at shorter time intervals on the tables, where their greater thickness requires longer cooling time. Thus the change from sheet to plate rolling requires considerable lengthening of the run-out tables on the finishing end with the consequent necessary lengthening of the building if this change-over was not previously anticipated. Other alterations in the plant layout may be required for handling, since the coilers and packs for strips are not suitable for plate. Flattening equipment for plates must be made heavier than for strip. Cranes, handling equipment, and auxiliary tables must all be adapted to the thicker products. In many instances the shears for cutting the thinner stock are too light, and must be remodeled or replaced with heavier shears to cut the thicker sections.

A number of plants have already provided for this change from strip to plate rolling on the continuous 4-high mills. It is expected that many others will make the change to provide plate for the ships, destroyers, submarines and tanks that are required in the present dangerous and hard striking world to completely protect our country.

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Providing cupola hot metal for charging open-hearth furnaces, when blast furnace metal is not available, offers many time-saving advantages over the cold charging method. The iron charges are melted in a cupola tapped into a large reservoir holding ladle for mixing and desulphurizing and then this hot metal is charged into the open-hearth for further refining.

—Whiting Corporation

★ ★ ★

A manufacturer of forgings substituted 3 in. thick silicon carbide tile in the hearth of under-fired annealing furnaces handling heavy loads. Production increased 400 per cent due to the high conductivity of the silicon carbide, which gave faster furnace come-back and greater heat flow through the hearth.

—Carborundum Co.

★ ★ ★

Speed-up in furnace installations may be brought about by using refractory concrete. This concrete is made with calcium-aluminate cement. Mixtures of refractory aggregates and calcium-aluminate cement can be cast in place, thus saving construction time, and shapes of all kinds can be pre-cast ready for installation as needed.

—Atlas Lumnite Cement Co.

★ ★ ★

An important factor worth considering in any program for faster production is the needless waste of virgin metals. A planned system at the source to segregate all skimmings and mill each alloy separately for direct remelting will eliminate losses of time and metal.

—Dreisbach Enginering Corp.

★ ★ ★

The use of soda briquettes for desulphurization of blast furnace iron speeds up production by saving time in the open-hearth because of lower preliminary sulphurs. It also gives increased iron production and enables more tons of saleable pig iron to be produced by desulphurizing iron to specification.

—Pittsburgh Plate Glass Co.

FASTER PRODUCTION
—FABRICATION AND TREATMENT

Forging of Shells

by F. G. Schranz

Gen. Manager,
Baldwin Southwark Div.,
The Baldwin Locomotive Works
Philadelphia

Considerable improvements in methods and equipment in the forging of rifled-bore shells have been made since the last Great War.

Twenty-five years ago the tolerance on the shell forging was more liberal than today, which required more machining time due to the removal of more metal from the rough forging in the machining operation.

The inside cavity of the shell, instead of being machined, is now smooth forged to the finished shell dimension. The eccentricity allowance in the rough shell forging nowadays is very small.

All of these close tolerances in the forging of shell bodies accomplish a great saving in the weight of the rough forging, which, even if only a few pounds per forging, will amount to several millions of pounds of steel per one million of shells. On a recent order for 155 mm. shell, which is specified to weigh 150 lbs., a saving of up to 10 lbs. per forging was possible, thus allowing the steel mills to produce more shell blanks per ton of steel.

The furnace builders also have improved the method of heating billets for shell forgings by introducing furnaces of either the rotary type or the automatic feeder type, which will heat billets up to 6 tons per hr. to a temperature of 2100 deg. F.

Forging methods also have improved. Several high speed hydraulic press installations are now producing 250 to 300 shells per hr. of 75 mm. with two piercing presses and only one drawing press.

High speed shell rolling mills are said to produce also 300 of such shells per hr., requiring automatic rotary type piercing presses, or several upsetters for one mill.

Another hydraulic press using the one-shot method produces a shell forging with one stroke of the press. Several types of mechanical presses are also used. The conventional horizontal forging machine or upsetting machine of several makes has been redesigned for high speed shell forging work, where a round bar in five stages with five strokes of the machine completes a forged shell body.

Another type of mechanical shell forging machine extensively used in England and Australia and recently built here, makes the piercing and drawing operation with one stroke of the machine, thus producing as high as 200 forgings per hr. with a 125 h.p. motor.

A mechanical bulldozer such as used in forge shops has been converted into a shell forging machine which, with only 75 h.p., will produce 75 mm. shells up to 120 per hr.

The steel specification issued by the Government also eliminates the heat-treating of forgings, all of which helps to speed up production.

[For details of the various forging methods see an article, "Modern Shell Forging Methods," by the author in the September issue of METALS AND ALLOYS.]

★ ★ ★

High nickel steels now can be annealed and cooled directly in salt baths from gas carburizing furnaces. No scale is formed, and Rockwell "C" hardness of 25-30 can be produced. The cooling cycle time, ready for machining, is only 1 to 2 hrs.
—A. F. Holden Co.

★ ★ ★

Draw-Tools of Carburizing Steel

by L. J. Weber

Metallurgist, Aluminum Cooking Utensil Co.,
New Kensington, Pa.

Under present conditions, many fabricating shops are experiencing difficulties in obtaining tool steels for draw-dies and punches used for deep drawing. The limited number of toolmakers also makes it imperative to decrease the time for making such tools to the very minimum.

Preliminary tests on alloy carburizing steels reported 2 yrs. ago ("Drawing of Aluminum", L. J. Weber & J. T. Weinzierl, *Trans. Am. Soc. Metals,*

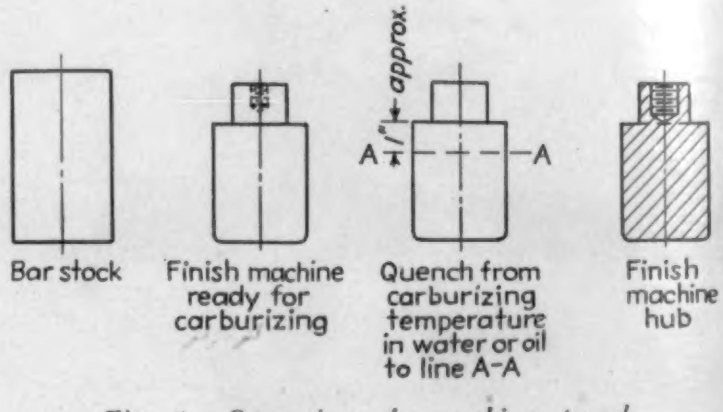
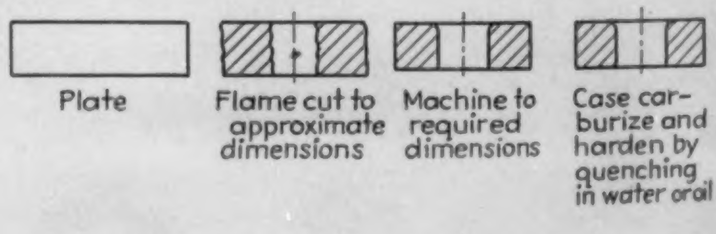


Fig. 1 Operations for making punch.

Fig. 2. Operations for making die.



Vol. 27, 1939, pp. 1052-1071) showed that they were entirely satisfactory for drawing aluminum. Further tests have corroborated these findings so that this type of steel is being used to a considerable extent in our plant at the present time. Even though we have not used these steels for drawing other metals it would seem that they should give satisfactory results in many applications, where tool steel is now being used.

An outline for the operations in making a punch is given in Fig. 1; Fig. 2 gives the operations for making a die. The carburizing steel, for example, S.A.E. 4615 is purchased either as plate or bar stock. The steel from the bar stock is machined to the proper dimensions while in the annealed condition. If plate stock is used, the rough shape is obtained by flame cutting, leaving only a small amount of stock for finish machining.

The finish-machined parts are case carburized at 1750 deg. F. to obtain a 1/32-in. case and allowed to cool to 1550-1600 deg. F. Dies that require no further machining are then quenched in water.

In the case of punches where some machining is required in the hub, the tool is plunged into the water only as far as the line A-A. This hardens the lower part of the punch, which is the surface that requires the high wear resistance, and leaves the hub soft enough to be machined and threaded for the nipple used to attach the punch to the press.

The hardened parts are tempered at 350 deg. F. for 2 hrs., so as to obtain a surface hardness of Rockwell 58 to 62. For complicated shapes it may be necessary to oil-quench in order to avoid severe distortion.

Even though S.A.E. 4615 has been used chiefly in our plant, other carburizing steels, such as 1015 and 3315, have also given satisfactory service in a number of applications. Our results to date show that the carburizing steels are suitable for many tools used in the deep drawing of metal sheet. A considerable saving in time and expense can be made by selecting applications where the carburizing steels will give just as satisfactory service as tool steels.

★ ★ ★

Time is saved in the normalizing of forgings by using salt bath treatments. This process eliminates scale, requires no pickling, permits a controlled cycle, saves fuel, speeds handling time, and reduces costs.
—A. F. Holden Co.

★ ★ ★

At one large steel treating company a side opening bar heating furnace is being charged and discharged in approximately one-fifth of the time that was formerly required to handle the same charges of long, heavy bars for gun recoil mechanisms in an end opening furnace.
—Lee Wilson Sales Corp.

Machining—Old Machines and New Men

by George T. Trundle, Jr.
President, The Trundle Engineering Co., Cleveland

The mechanical engineering and industrial engineering principles set forth in this article apply so broadly that we welcome the opportunity of presenting them to metallurgical engineers, many of whom are entrusted with the job of increasing the output of machining operations, but without benefit of new, highly accurate machine tools.—The Editors.

It is so easy, so tempting, to assume that defense production will all be handled by vast new plants equipped with the most modern machine tools, operated by the finest of skilled mechanics. Unfortunately this Utopia does not exist.

We haven't enough new machine tools for the whole defense job, and we can't get enough new machine tools in time. We haven't enough skilled mechanics for the whole defense job, and we can't train enough new skilled mechanics in time.

The hard fact is that we must do a very large share of the national defense production job on old machine tools operated by green hands. This means analvzing the performance possibilities of old machine tools, analyzing the jobs to be done, and giving the old machine tools the jobs which they can do in the light of the limitations which they possess.

Not every national defense production job requires accuracy to two-ten-thousandths of an inch. It is not necessary to put every national defense production job on a modern, multiple-operation machine tool. It may be possible to do a great deal of the work on a succession of older machine tools if the steps are broken down into the proper sequence of operations.

To illustrate—if an old machine will not hold a reamed hole to size, rough it on an old machine, take it off and ream it on a more accurate machine. If an old machine will not hold the thread to size, rough it on the old machine, take it off and run a die over it by machine or by hand. If an old machine will not hold concentricity or an accurate outside diameter, make a secondary operation of it on another machine. In short, give the old machines all the work they can do within their limitations, and thereby release the new machine tools for the more accurate jobs, which the old machines are incapable of performing.

Now as to men—the situation is the same as it is with machines. We cannot afford to say, "We can't use untrained men because of their limitations." It is instead our job to figure out how we *can* use untrained men *in spite of* their limitations. And how will we do this? By teaching a green hand to do *one thing well.* A machine may be able to do 5 things

well, but that won't help you with a green hand. Performance of a machine is limited by the understanding and skill of the operator.

Operations must be broken down into a sequence of simple steps. Each new man can then be trained to handle one of these steps. This does not make him a master mechanic, nor does it even make him a fair machinist. But it does make him a production cog in the national defense program. And he can be trained to his one job well in a matter of weeks.

The point is that with volume production the net output that may be obtained by the above method may come very close to that which might be obtained with highly skilled men. To illustrate the principle involved—Suppose you have 4 identical turret lathes with 4 skilled operators performing, in succession, 4 operations on a given part to be produced on each lathe. This is fine if you have skilled operators. But suppose you have green hands. What do you do then? You set up each lathe for a single operation. You teach the first green hand to do operation #1, the second green hand to do operation #2, etc. You pass the work from the first machine to the second, to the third, and to the fourth.

The net output, on this basis, is just as large with four green hands who have learned only one operation as it would be with four trained hands who could do four operations on each machine! In fact, output may eventually be larger, because there is no set-up time. Each machine remains set up for a single operation.

And it often happens that the most practical way to use an old machine is to pick out one particular job which that machine is capable of performing and keep it at that job all day long. Therefore, take a new man and train him to do that job on that machine all day long.

This prospect may be not in the least alluring to an engineer who thinks in terms of modern, perfect machines and skilled mechanics. But it is a method that will enable us to put to work on national defense production every existing machine tool, no matter how old it may be, and every bit of our manpower, regardless of training or experience.

It is to my mind the only method that will enable us to get this national defense production job done *in time.*

★ ★ ★

Castings made of cast iron, cast steel, malleable iron, Monel, nickel, bronzes, aluminum, etc., which might ordinarily be rejected can be salvaged by repairing with eutectic low temperature welding alloys. The casting will not be affected by low temperatures, the weld is color-matching, with very high physical properties and, further, is easily machinable. Therefore, vital metals as well as expensive machining operations can thus be saved.

—Eutectic Welding Alloys, Inc.

Machining with Carbide Tools

by James R. Longwell

Chief Engineer, Carboloy Co., Inc., Detroit

Virtually no one any longer questions the fact that you can cut metals faster with carbide tools. A point often forgotten is that this great increase in cutting speeds of itself does not necessarily mean the attainment of a corresponding increase in the amount of finished product that reaches the shipping platform every 8 hr. shift.

It is quite true that the substitution of carbide tools without any other major alteration in the set-up except an increase in cutting speed, will step up production somewhat. Carbides will stand it, and carbides—normally—will produce a far greater number of pieces per grind.

However, to take advantage of the maximum increase in productivity possible with carbide tools, other factors must frequently be taken into consideration. Among these are:

1. Tool holders and tool mounting
2. Machine conditions
3. Employment of coolants
4. Proper care of tools.

To begin with a different type of tool holder is frequently needed for carbides than for high speed steel. Carbide tools need a rigid support. They should be lined up to cut virtually on-center. Tool overhang should be held to a minimum to prevent chatter and possible breakage.

Demountable Tool Holders

In addition, however, carbide tools make possible a vast reduction in machine down-time by the employment of a simple device: quick-demountable tool holders. When these are used, tools can be ground and adjusted to cutting position in the tool room. When it is necessary to change tools one tool holder is merely removed and a new one slipped in place. At most only a slight touch-up adjustment is needed —usually not even that—and the machine is running again. Where several tools are used on one machine, the saving in time mounts up.

Again, it is possible to use carbide tools on most old machine tools without difficulties. To get the most out of such tools, though, machines should be carefully looked over and tightened up where excessive backlash exists, to eliminate chatter and vibration.

Horsepower should be checked, for frequently it is found that the only reason machines are not producing more with carbide tools is that the motors with which they are equipped are too small to handle the load when carbide tools are used at their full capacity.

Not infrequently this results in machines being

run too slow, not only from a production standpoint, but also for good cutting efficiency. This is particularly true in steel cutting, where cutting speeds with carbide tools should be high enough to prevent a "build-up" on the cutting edge. Unless this is done, carbide tools cannot be expected to give their best performance.

Use of Coolants

The proper employment of coolants is another big aid to improved performance with carbide tools. The fundamental principle required is that the coolant should be supplied copiously and at high velocity. Carbide tools by virtue of their faster cutting alone, generate more heat. The coolant must carry this off. Sometimes coolant piped through the tool holder, or directed at the work from below has helped to step up production.

Care of Tools

Proper care of carbide tools is another important contribution toward getting increased production. Carbide tools should never be run until they will no longer cut. Long before this, the cutting edge may have started to dull slightly, reducing cutting efficiency, increasing spoilage, etc. Tools should be periodically inspected for cutting condition, or removed for grinding at specified intervals. If dulled, they should be replaced and reground.

Carbide tools can be ground at high rates of speed when correct grinding technique is employed, and tools are kept moving. They should never be dipped in water, etc., when hot.

High Speed Steel Tools

by J. V. Emmons

Chief Metallurgist, Cleveland Twist Drill Co., Cleveland

While it might be helpful, from the faster-production viewpoint, to stress the possibility of saving much machining time (and thus increase effective machine-tool capacity) by employing high speed steels in place of other tool steels whenever possible, this space can be better spent in outlining ways of getting the most tool-production and part-production out of high speed steels.

In other words, let us just assume that high speed steels have been chosen wherever they should be used, but that information is generally needed on their working, treatment and use—as indeed it is. The remarks that follow apply to all types of high speed steel, although with special emphasis on molybdenum-type steels—since by OPM order they are now more widely used than ever, and sometimes by men who previously have had little experience with them.

Maximum *part*-production is achieved with highest-quality tools—tools with longest life between grinds and consistent high-speed performance. Maximum *tool*-production depends on careful selection and inspection of high speed tool steel and intelligent processing to avoid waste motion and reduce tool spoilage.

Uncertainty as to heat treating procedures can be a real source of delay. With the molybdenum-type high speed steels, heat treatment practice is essentially the same as for the 18-4-1 type, except that the forging and hardening temperatures are lower. For example, the "Mo-Max" molybdenum-tungsten high speed steel, which has had the longest period of use and the broadest commercial application among the molybdenum types, requires the following temperatures: Forging, 1950 deg. F. as compared with 2100 for 18-4-1; Hardening, about 2200 deg. F. as compared with 2350 for 18-4-1. The molybdenum-type steels must be more carefully protected against decarburization during hardening than the 18 per cent W steels. This last is a difference of degree, however—*all* high speed steels must be so protected, and practice that is bad for moly steels is almost certainly damaging to 18-4-1 as well.

Pre-Testing

Much time and tool spoilage could be saved, particularly in small shops, by extending and intensifying steel inspection methods. This is particularly important now when new steels are the order of the day to many shops. Fortunately, steel inspection can be combined with practice in hardening to work out the best procedure for hardening tools.

All kinds of tool steel suffer varying amounts of surface decarburization or "bark" during manufacture in the tool steel mill. The depth of this on high speed steel can be determined by the soft skin on the original surface after hardening and tempering. The hardness can be determined by any available method. The toolmaker's machining practice should be regulated to insure the removal of this "bark" before tools are hardened. Other defects sometimes found during the inspection are mixed steel, segregation, blow holes, slits or bursts, and surface seams. A study of the grinding sparks is valuable in discovering and sorting mixed steels.

A simple and trouble-saving way of determining the best hardening practice for a new lot of high speed steel is to cut a small disk from one of the purchased bars, give it to the hardener and have him harden it by the method and with the equipment to be used for the tools. Then make hardness and fracture tests and compare the hardness and fracture with those of a satisfactory used tool of either 18-4-1 or molybdenum-type high speed steel, and, also, if possible with bad tools.

Forehandedness of this type eventually saves much time, trouble and steel. Particularly in the case of a new type of steel, it is obviously much wiser to practice on small inexpensive disks than on finished tools. Even if no hardness tester is available, an intelligently-made file test will do; an experienced man can tell when the bite of a good file on a hardened test piece is like or unlike its bite on a satisfactory tool.

Heat-Treating Practice

High speed tool blanks should be full-annealed, at 1500 to 1550 deg. F., with very slow cooling. Tools should be protected against decarburization by packing in cast iron chips, in ashes containing some powdered charcoal, in powdered mica with 5 per cent charcoal, etc. The hardness of the "Mo-Max" molybdenum-tungsten type after annealing will be 3-6 pts. Rockwell "B" lower than that of 18-4-1, and the steel is slightly more machinable in this condition.

It is unnecessary to junk old furnace equipment that has been found satisfactory on high-tungsten steels, just because molybdenum steels are to be employed. Any really *good* furnace can be adapted to the moly steels with little if any modification.

For high-production requirements, salt bath furnaces are ideal, and some of the modern systems are particularly suited to the demands of "faster production." For small lots or occasional work, however, other types of furnaces are likely to be more economical or even more time-saving.

Controlled or prepared atmosphere furnaces, if the atmosphere is *really* controlled with respect to oxygen, water vapor and carbon dioxide, are quite satisfactory for high speed steel treatment. Also, furnaces that depend on the gradual combustion of a carbonaceous muffle or charcoal block for their protective atmospheres are highly useful if care be taken to avoid excessive *carburization* of the work.

There are at least 2 simple "manual" methods of protecting high speed steels against decarburization when the furnace conditions are not the best. In one, a copper paint or similar coating is applied to those surfaces that must be protected. In the other, the salt bath effect is simulated by sprinkling the surface of the tool with powdered borax (silicon carbide hearths, however, must be protected by a steel plate, preferably stainless, against the action of the molten borax). Both of these methods are effective and in fairly wide use.

Quenching is done in oil or in a low temperature salt bath as desired. For maximum toughness or to avoid warping intricate tools an airblast may be used. Straightening if necessary should preferably be done before the tempering.

Tempering is carried out the same as for 18-4-1. In tempering, some production time may be saved by recognizing that the double draw, while sometimes desirable, is not essential with high speed steels. On the other hand, time-saving should never be carried to the extreme of quenching from the tempering temperature—cooling from this temperature must be slow to bring out full secondary hardening.

These are simple, practical (perhaps to many, obvious) points, but their careful observation is the best method known to us of assuring maximum production of tools and parts through the use of high speed steels.

★ ★ ★

Graphoid-surfacing of mandrels and piercers for the hot forging of 75-mm. shell is apparently proving effective in vastly increasing the life of these tools, preventing sticking, and insuring greater forging uniformity. With this process, output of 14,-000 shells was obtained in one case against a former 6,000 to 8,000 shells.

—Acheson Colloids Corp.

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Atmospheres for Molybdenum High Speed Tool Steels

by A. H. Koch

Engineer,
Surface Combustion Corp.,
Toledo, Ohio

At the start of Wold War I the best and most popular types of tool steels contained tungsten as the primary alloying element. Conditions during that war seriously reduced the availability of tungsten which resulted in the return to the use of the common high carbon types of steels for tools. This, in turn, resulted in reduced production and a considerable increase in production costs to many manufacturers.

Since that time extensive research has resulted in the development of a high speed steel containing but little tungsten. The primary alloying element in this steel is molybdenum, hence, the commonly used name: "Moly high speed steel." This steel has proven to be in general as satisfactory as tungsten high speed steels for most machining operations and for some uses has proven to be superior.

Conditions have not changed sufficiently to eliminate a shortage of tungsten during the current war. Fortunately, however, a substitute of proven quality is today available in the moly type high speed steels. Reduced production and increased costs need not be tolerated because of a lack of tungsten.

As is usually the case when substituting one material for another, certain characteristics prove to be advantageous while others frequently prove to be the opposite. Therefore, means must be devised to overcome objectionable features of the substitute to make

it as satisfactory as the original material. Molybdenum as an alloying element materially increases the rate of decarburization of a high speed tool steel, when heated to high temperatures for hardening.

Constant improvement in the art of heat treating tungsten high speed steels has brought about the use of gaseous atmospheres to reduce scaling and decarburization of the steel, while at high temperatures, to a minimum. This development has reduced the necessity of the salt bath and the use of protective coatings, which are difficult and costly to remove from the surface of the steel after heat treatment.

The increased tendency to decarburize, caused by the molybdenum in the steel, render gaseous atmospheres, which are satisfactory for tungsten high speed steels, entirely unfit for the moly high speed tool steels. The moly high speed steels require a much more refined atmosphere than do the tungsten types of steel to prevent serious decarburization. The gaseous atmosphere for a moly high speed steel must be very high in carbon monoxide content with only a very small carbon dioxide content and be practically free of water vapor.

Fortunately, within the last few years a simple, inexpensive means of generating such an atmosphere has been developed. It is done by passing air through a bed of heated, dried, and degasified charcoal. This development has made it possible for industry to utilize moly high speed tool steel without having to revert to the older, cruder, more troublesome, and more costly methods of heat treatment.

In a char-gas (generated from charcoal and air) atmosphere molybdenum high speed tool steels can be hardened as easily and with as satisfactory results as can any other high speed tool steel by any other known method of heat treatment.

Rearmament and Heat Treatment

by E. G. de Coriolis

Director of Research,
Surface Combustion Corp.,
Toledo, Ohio

Speeding up of production in plants now engaged in rearmament is best accomplished by adopting methods which have proven their merit in modern peace-time practice. In the field of heat treating, probably the one single item which has contributed the greatest advance is the specialized atmosphere furnace.

The word "specialized" is used to emphasize the necessity for choosing equipment which is adapted to the specific requirement of a given operation. The atmosphere heat-treating furnace is not universal, and if it is to fulfill its function in speeding up production, it is important that it be selected for the job at hand. This can best be illustrated by analyzing the requirements of a recently constructed armament plant built especially for the production of mechanized ordnance.

The parts requiring heat treatment involved a miscellany of gears, shafts, pins, bushings, etc. Some had to be carburized, cooled, reheated, quenched and drawn. Others were of medium and high carbon steel. The quantities of each part were small but the total number and tonnage of all parts was appreciably large. The size, weight, and shape of the individual parts varied widely.

To meet the conditions for carburizing, it was found that the best overall equipment would be represented by the radiant-tube batch gas carburizing furnace. This involved new design of a type never heretofore constructed. Nevertheless, previous experience in the automotive field indicated the probable workability of the equipment which actual operation has since confirmed.

Reheating of carburized parts as well as heating for quenching of medium and high carbon parts called for non-scaling and non-decarburizing furnaces, atmospheres for which had been previously developed. The handling of such a miscellany of parts presented, however, some difficult problems in the size and type of equipment. The final solution consisted in using a rotary hearth radiant-tube furnace for all parts that would be no longer than 30 in. and no higher than five in. The extra long and extra heavy shafts and other pieces were reheated in a batch-type muffle furnace. Excellent results are being secured from both types of equipment.

The above would seem to indicate that, in the field of heat treatment at least, adaptation of the latest developments in this art to the implementing of rearmament plants, with such modification as may be required, presents the best assurance in speeding up production of the new tools of modern warfare.

★ ★ ★

In machining, soluble oil allows the use of increased cutting speed, provides an increased tool life, and gives a surface finish better than that obtained by a rough grinding operation.

—Advanced Cutting Fluid Co.

★ ★ ★

The two-chamber elevator furnace offers a production equipment for short-cycle annealing of malleable iron where continuous-type furnaces are not warranted. One chamber is used for the low-temperature part of the cycle and the other chamber for the high-temperature part of the cycle, thereby saving in time of heating and cooling, and in energy consumption.

—General Electric Co.

Tool Life

by O. V. Greene

*Assistant Metallurgist,
Carpenter Steel Co.,
Reading, Pa.*

One of the secrets of faster production is the reduction of time lost because of the premature failure of tools. Each time a press or machine must be shut down to replace or recondition a tool, valuable time is consumed. Many tool failures, such as "loading," "scratching," "wearing oversize," etc., are regarded as necessary evils and no particular attention is given to the problem of improving tools. Tool failures in many plants are one of the unsuspected bottle-necks that upset production schedules. In the majority of cases, tool failures are caused by lack of attention to small details, and considerable improvement can be accomplished by very simple means.

To illustrate this point, here is what was accomplished on a single press job by correctly analyzing the tool problem. Upon drawing a bearing retainer of hot rolled steel, $1/8$ in. thick, the die ran oversize after about 4000 pieces. The part and tool are shown in Fig 1. The rated capacity of the press was 1250 pieces per hr., and replacement of the tool with a duplicate consumed one hour, during which the press was idle. It is a matter of simple arithmetic to determine the number of productive hours lost in a day. In solving this problem, the "Good Tools Formula" was applied. This is:—

Good Design × Good Tool Making × Good Tool Steel × Good Heat Treatment = GOOD TOOLS

The result was an increase in tool life from 4000 to 86,000 pieces per tool. This represents a decrease in press shut-down time of 42 working hours per month or a gain in production of 52,500 pieces per month.

Space does not permit of a full discussion of all the factors of the Good Tools Formula. "Good Tool Design" and "Good Tool Making," involve attention to mechanical details, such as unbalanced sections, sharp keyways, etc. "Good Tool Steel," means not only the finest quality, but a steel accurately selected for the application. However, here are a couple of quick tips on the last factor, "Good Heat Treatment," as applied to press tools:

Scratching or loading are nearly always caused by a soft skin or soft spots on a tool. A tool which has a glass-hard surface certainly will not score and pick up as readily as one with a soft surface. The soft skin or decarburization can be prevented by using the correct furnace atmosphere. Most oil and water-hardening tools whose correct hardening temperature lies between 1425 and 1575 deg. F. should be heated in an oxidizing atmosphere. This atmosphere usually contains from 2 to 4 per cent oxygen. There is a very simple test for estimating this amount of oxygen in a furnace atmosphere. If a wood block, about $3/4$ in. sq., is placed in the furnace and observed through the peep-hole, and it burns with a flame which is about half blue and half yellow, the oxygen content of the furnace atmosphere is between 2 and 4 per cent. The appearance of a wood block in such an atmosphere is shown in Fig. 2. Hardened from such an atmosphere, most water hardening and oil hardening tool steels will come from the quench fully hard right out to the surface. (If the wood smokes with no flame, or if it burns with a blue flame only, the oxygen content is usually lower than 2 per cent. If it burns with a steady, yellow flame and the remaining charcoal glows, the oxygen is usually in excess of 5 per cent.)

Soft spots, as a rule, are encountered during water quenching. They are caused by the presence of atmospheric gases dissolved in the water, which are liberated on the face of the tool when it is quenched, thus insulating certain areas. An addition of about 5 to 10 per cent of salt minimizes the possibility of soft spots. This amounts to about $3/4$-lb. of ordinary

Fig. 1. The part and tool; 42 more productive hours per month per press.

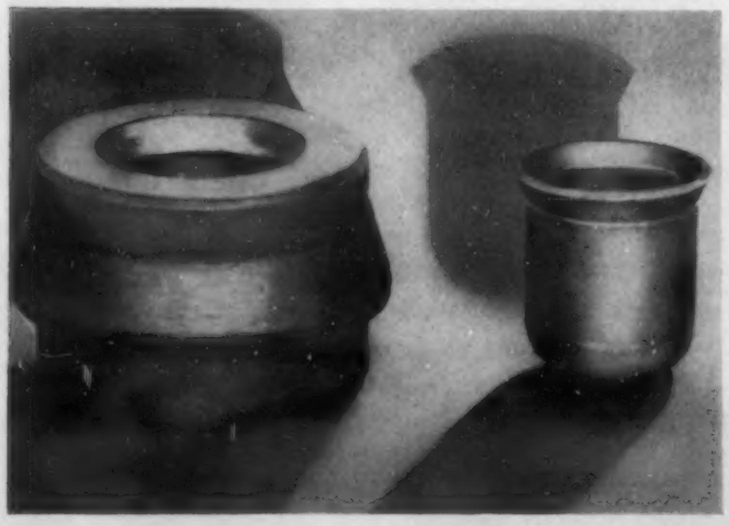
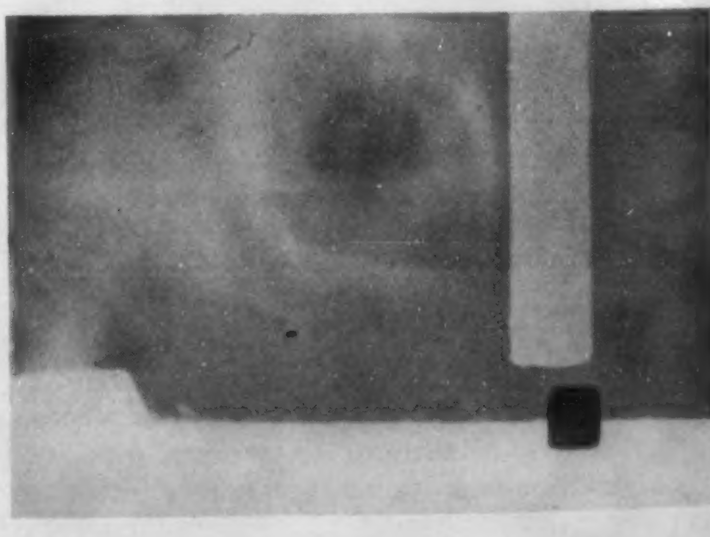


Fig. 2. Wood block test showing 2 to 4 per cent oxygen furnace atmosphere.



rock salt per gallon of water. For steels which are to be oil quenched, a good grade of commercial quenching oil when maintained between 90 and 140 deg. F. is recommended.

Moral: Get better production from your presses by making sure that the tools are free from soft surface.

★ ★ ★

The application of high speed automatic "tablet presses" to the compressing of metal powders for making such molded parts as bearings, small gears, motor brushes, contacts, etc. has enabled several concerns to manufacture these parts at a tremendously increased rate of production.

—Kux Machine Co.

★ ★ ★

Heat Treatment of Tools and Dies

by R. B. Seger

Superintendent,
Lindberg Steel Treating Co.,
Chicago

Hardening and tempering of tools and dies is an operation which cannot be hurried. In fact, giving this operation more time will probably result in the increased production for which we are all striving. There are a few points which if adhered to will not necessarily hasten the heat-treating operation but they will certainly help to prevent delays.

1. Remove all surfaces of the tool as recommended by the steel supplier, to insure a cutting edge free of decarburization. Very often the tool is completely hardened and tempered before this decarburization is discovered. This necessitates annealing and rehardening in a pack to build up the surface with carbon. The pack treatment is a lengthy one and even though the surfaces are hard it may not give the production that a tool free from decarburization would give.

Some plants will spend many hours grinding off the soft surface rather than reharden by the pack method. This procedure is obviously wasteful of time and money.

2. Be sure of the steel that is being used and convey this information to the hardener. Do not expect the hardener to treat a piece of steel and keep it in one piece if he doesn't know whether it should be quenched in oil, air or brine.

3. Leave fillets in corners whenever possible so that the hardener doesn't have to pray that the die will not crack at that sharp corner.

4. Finish all surfaces in the same manner. A die having a smooth ground surface on one side and a rough machined surface on the other, will always warp in hardening because the ground surface will quench faster than the machined side, making a difference in contraction rate.

5. Many plants are wasting many hours grinding decarburization off of tools that has occurred during heat treatment. Progressive manufacturers long ago recognized the importance of the heat-treating operation, and the skill required to produce consistently good hardening. But all the hardening skill in the world will not offset the lost time and extra expense caused by poor hardening equipment

Boring mills, lathes, grinders, etc., have all seen vast improvement in the past years. Furnace manufacturers have been just as alert as machine tool builders and those who realize this fact are receiving large dividends. The modern furnace equipped with atmosphere is capable of hardening most steels so that decarburization and scaling are eliminated.

Proper hardening of tools, providing the designs are not too impossible and the proper equipment is used, will leave them with practically no decarburization (soft skin) no scaling and no distortion.

★ ★ ★

The time required in one New England plant for pack carburizing miscellaneous automatic-machine parts was cut from 12 hrs. to 8⅔ hrs.—production rates accelerated 38 per cent—by installing a gas-fired radiant roof in each of 8 box-type furnaces previously heated by sidewall electric elements. In addition, costly hearth reconstructions for underfiring were obviated, fuel costs reduced, and temperature uniformity improved.

—Selas Company

★ ★ ★

An aid in reducing the time required to get into production is the introduction of adjustable die sets. These dies can be most advantageously used for limited-quantity production. Various sizes of punches for perforating and notching can be arranged in different positions to suit the requirements of the job in hand.

—S. B. Whistler & Sons, Inc.

★ ★ ★

Heat Treatment of Parts

by J. F. Wyzalek

Chief Metallurgist,
Hyatt Bearing Div.,
General Motors Corp.,
Harrison, N. J.

As a speed up heat treating operation, the high frequency induction heating method fully meets this requirement. It offers split second precision, a means of heating of only a few seconds duration, for annealing, hardening, or tempering of steel parts. It frequently permits the use of plain carbon steels in place of the alloy steels often necessary when the conventional heat-treating methods are applied. Localized heating of the most intricate parts is practical. Distortion is minimized while decarburization and oxidation are practically eliminated. As a result, treated parts require very little or no grinding. Such articles as crankshafts, camshafts, axle shafts, wheel hubs, bearing races, bushings, are in increasing amounts being induction hardened, thereby saving

not only considerable amount of process time but also offering improved service performance at lower overall cost.

In the present Defense Program, it is the ideal means of speeding up armament production of many ferrous parts which require some form of heating. It opens an avenue of approach that can result in a saving of time and a simplification of process to some of the present ordnance problems, particularly those pertaining to armor and armor piercing shot where the conventional methods of carburizing and heat treating are at best very lengthy, of limited flexibility, and costly. Due to its precision control of depth of heat penetration a more uniform product is possible, which should be reflected in improved performance.

To permit the application of induction heating promptly and efficiently to our various Defense requirements, it is necessary that industry immediately become more conscious of the extensive possibilities of this modern means of heating.

Another rapid method is flame hardening. Although not as fast as induction heating, it, however, offers considerable saving of time as compared to conventional methods. It is especially adaptable to large sections requiring localized heat treating. Gears, shafts, and cylinders are flame hardened satisfactorily. The secret of success is the close control of all factors to obtain uniform penetration of hardness to the desired degree.

Steel forgings and castings requiring long heating cycles of 10 or even 60 hrs. for developing the necessary hard case depths can be flame hardened to equal depths in a matter of only a few minutes. Also flame hardening offers a solution to the old problem of machining chilled cast iron by allowing the complete machining of soft castings to be followed by flame hardening the desired areas within close metallurgical limits accompanied by minimum distortion and negligible oxidation. More extensive use of this method should be encouraged, especially in view of its relatively low investment cost and adaptability to large intricate parts requiring localized heating.

★ ★ ★

Hard-facing of vital parts subject to abrasion is a smart, economical time-saver. It gives longer life to parts by offsetting wear. Where replacements are difficult to obtain, the old parts can be rebuilt by hard-facing and quickly put back into service.

—Haynes Stellite Co.

★ ★ ★

A problem, now particularly costly from the time standpoint, has been the breaking of tool shanks on multiple tool heavy duty lathes. The use of special high-strength cast irons, with their inherent vibration dampening qualities, will eliminate a great number of these tool shank failures.

—Meehanite Research Institute of America

Carburizing

by E. F. Davis

Metallurgist, Warner Gear Div.,
Borg-Warner Corp.,
Muncie, Ind.

The present Defense Program and resulting production demands has put into use practically every known type of carburizing equipment. In many plants we find ancient and once scorned box furnaces now in full time operation carburizing parts for army trucks, tanks, and other ordnance materials. In the aviation engine industry the favorite furnace appears to be the pit type carburizer using oil or gas for the carburizing medium. In the larger industries, such as the automobile and agricultural, the continuous gas carburizers are most commonly found.

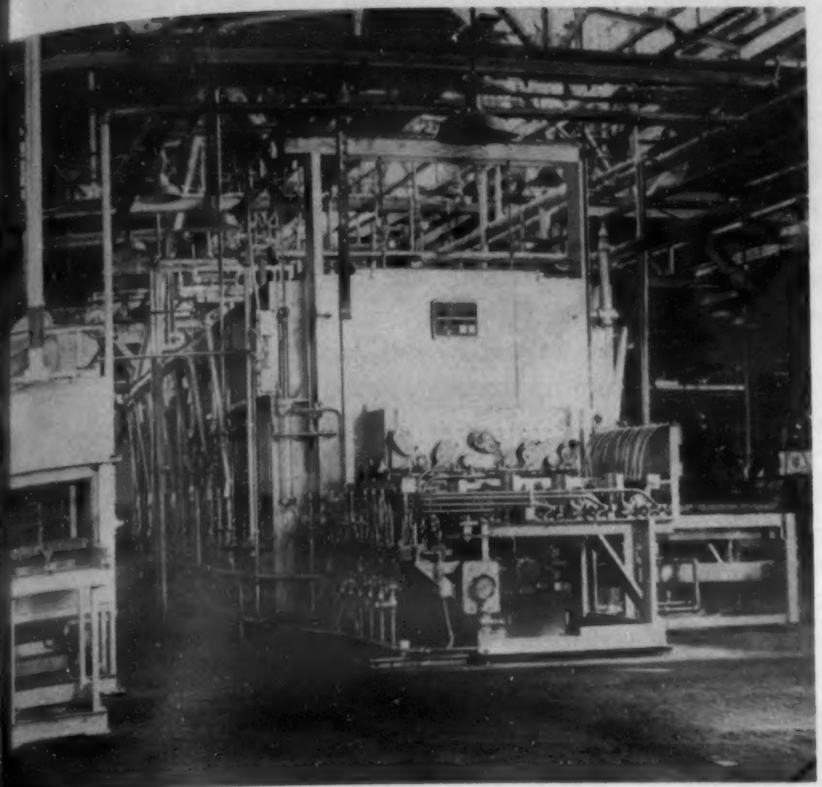
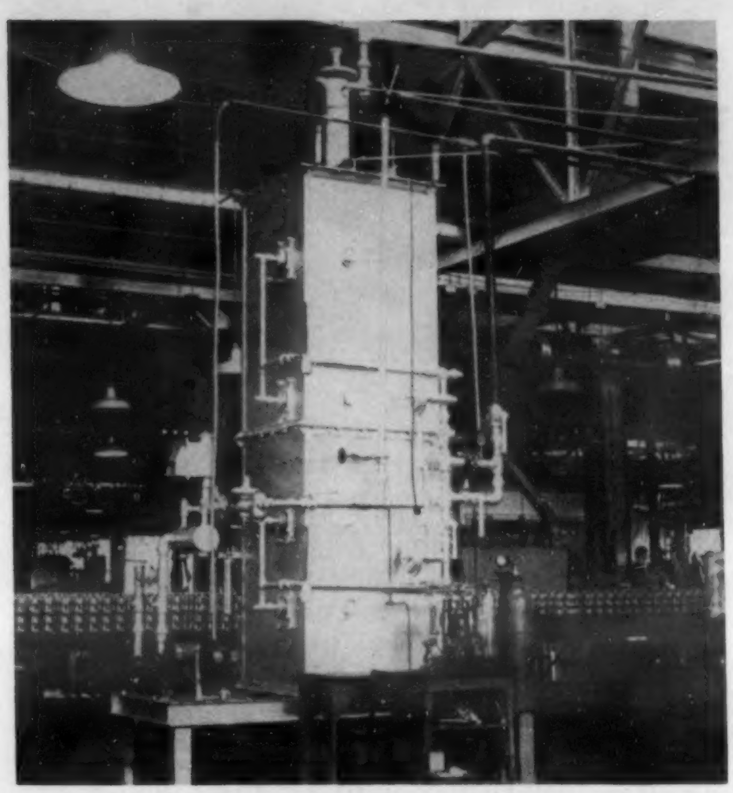
Many of the recently installed continuous gas carburizers are actually complete heat-treating units. They will automatically carburize, quench, wash, and temper the parts. One operating in a large gear plant also automatically burns off the trays and fixtures from carbon and oil.

Four Row Furnace

A typical illustration of the latest design is the four row carburizing furnace, utilizing independent control on each row so that a wide diversity of case depths is possible. One row could produce, for example, 0.040-in. case, another 0.050, another 0.060 and the fourth 0.070-in., and work of four different case depths may be going through the furnace simultaneously. Based on the fact that carburizing proceeds at about 0.012 inch. per hr. at 1700 deg F., it is merely a matter of the time in the furnace and, by slowing or speeding up the pushing intervals, any desired case may be obtained. This makes a very flexible unit for all rows can push on one case depth or several case depths, as desired. Or, if production should decrease, only one or more rows need to be operative.

Many of the new furnaces do not use muffles as formerly, but are fire brick chambers heated internally with radiant tubes or other forms of combustion cylinders. This permits a larger furnace area and improves production possibilities. These furnaces can be repaired quickly in the event of a tube burning out without loss of time, whereas, if a muffle burns out, often three to eight weeks' delay is experienced. The average muffle in a continuous gas carburizer costs about $12,000 whereas the radiant tubes are comparatively cheap; and although these latter must be replaced at intervals, yet there is not the outlay of money required of the muffle. However, it must be considered that in either type of furnace there is considerable alloy used.

In the early gas carburizers the gas was cracked either wholly or in part in the carburizing chamber.

The four-row pusher furnace (left) and the gas cracker. The gas is heated to 1800 deg. F. and passes through a tube of nickel oxide catalyzer. This installation is at the Warner Gear Div. of the Borg-Warner Corp., Muncie, Ind.

This produced considerable sooting and ultimate formation of graphite. This would pack into rail joints and in porous spots in the muffles, and much failure of rails and muffles has been attributed to the so-called "carbon explosions." In cleaning out a gas carburizer, it was not unusual to obtain several barrels of carbon deposit. This was evidence of gas wastage and imperfect cracking.

A Gas Cracker—Latest Innovation

The latest innovation is a gas cracker, exterior to the furnace, which completely decomposes the methane or propane by means of a catalyzer and produces a dry carbon monoxide in the carburizing chamber. This is introduced into the furnace with a small addition of about 2 per cent of raw gas. This produces clean work free from soot, very little deposition of carbon in the furnace, and less than 50 per cent of the gas formerly required is necessary for the carburizing operation. There is an improvement in the life of rails and fixtures, less frequent shut down due to furnace troubles and, most important, it is now possible to operate continuously for a month or longer without the weekly shut down for furnace cleaning.

There is now much difficulty in obtaining heat-resisting alloys due to the ban on nickel and chromium. Cast iron and welded low carbon steel has been substituted in many plants for fixtures employed in gas carburizing units. Cast iron would not have sufficient strength to withstand the pushing load, but seems to stand repeated quenching without cracking the metal. Cast iron fixtures have a tendency to grow alarmingly by repeated use. But if allowance is made in the design for this growth, about 250 heat hours can be expected, which makes them comparable in price to heat-resisting alloy, and more important, is readily obtainable. Welded fixtures made of steel will last about 400 heat hours and cost about twice those of cast iron. In this period of "ersatz" material, this offers a way out of the difficulty of getting heat-resisting alloy. The same is true of carburizing boxes in stationary and straight through furnaces.

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Putting tools to work immediately after drawing, by eliminating refinishing and straightening operations, is a real saving of time. The savings are especially important when large or long drills and reamers of high speed molybdenum, cobalt and tungsten steels are being hardened. These savings are made possible by a vertical muffle furnace using a carbonaceous black controlled atmosphere.

—Sentry Company

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The cleaning of drills can be speeded-up more than five times through the use of tanks containing a solution of potassium tallow soap heated by electric immersion heaters. The heated solution quickly removes the cleaning compound deposited on the drills by rotating brushes.

—General Electric Co.

Nitriding

by Horace C. Knerr

President,
Metallurgical Laboratories, Inc.,
Chestnut Hill, Philadelphia

Large amounts of nitralloy steel are being used in defense production, especially for military tanks and armored cars. Some parts are made from drop forgings while others are machined from bar stock.

In the development of nitralloy steel for the commercial market it has been customary to heat treat bar stock at the mill and then to machine it directly to size ready for nitriding, allowing only the necessary slight tolerance for final grinding. Where the parts were of such a nature that internal strains set up in straightening or in rough machining were likely to cause harmful distortion in the nitriding operation, an intermediate stress relieving treatment before finish machining was essential.

Purchasers of nitralloy bar stock (as well as of other engineering alloy steels) have recently been confronted with excessively long delivery schedules from the mills. Warehouse stock has been almost unobtainable. A considerable part of the delivery time has been represented by the heat-treating and straightening operations, due to overcrowded mill schedules for these departments. It has been found possible to expedite mill deliveries as much as six or eight weeks in certain cases by accepting the material in the hot rolled condition.

In addition to the time saved and the advantages of releasing mill equipment for other necessary defense production, this arrangement proves to be a source of further saving in time and in money to the purchaser. For parts requiring only limited machining it has sometimes been possible to do this in the hot rolled condition. This practice is not generally recommended. Where heavy machining is necessary, a simple and inexpensive low anneal at, say, 1300 to 1400 deg. F., is applied to put the material in satisfactory condition for machining. The parts are then rough machined, leaving approximately 1/32 in. on surfaces for finish machining.

The usual quenching and tempering treatment is then applied, consisting of a quench from 1700 to 1750 deg. F., followed by tempering at 1100 to 1300 deg. F. depending upon the final core hardness desired. This treatment, at the same time, effectually removes any internal stresses which might previously have been present. The special stress relieving anneal is eliminated.

The parts are next finish machined, ready for nitriding. This, of course, removes scale and decarburization caused by the heat-treating operation, as well as correcting any deformation which might have accompanied that process.

Considerable time in machining operations may be saved by this schedule because of the greater ease with which the annealed nitralloy may be rough machined compared with machining it in the heat-treated condition.

A somewhat similar process may be applied to drop forgings where much machining is required, first rough machining and then heat treating, instead of heat treating in the original forged state.

On a production basis, parts in their rough machined state can usually be heat treated at a price per pound comparable with the heat-treating differential charged on bar stock. This results in a considerable saving in heat-treating costs per piece because of the reduced weight.

Some users of nitralloy have reported difficulties in machining due to the hard scale resulting from the necessary high temperature quench and report a substantial saving from sand-blasting the parts prior to machining.

Oxyacetylene Flame Hardening

by J. J. Crowe

Assistant to the Vice President,
Air Reduction Sales Co.,
New York

In an effort to provide substitute materials with the qualities of formerly-employed materials now becoming difficult to obtain, engineers will develop in this emergency many new processing applications. In addition, processes that have been in use to a reasonable extent and have proved their adaptability to fast-production requirements, will be greatly expanded in their employment.

One such process is oxyacetylene flame hardening, in which surface areas of relatively large steel or cast iron parts are hardened by heating with an oxyacetylene flame, followed by immediate water-quenching. The chief and now generally recognized advantage of the process is its suitability for uniformly hardening localized or selected surface areas, without affecting the mass or core of the part, and with a minimum of distortion.

The process develops, of course, the full hardness of which a steel or iron is capable, and the metallurgical conditions as to compositions and hardened structures are similar to those for furnace-hardening. Flame-hardening is inherently suited to mechanization and thus conforms admirably to current "speed-up" demands.

An important strategic-alloy-saving advantage of the process is its use, in conjunction with plain carbon steels, to provide hard, wear-resistant surfaces where such surfaces had formerly been developed by furnace-heating and oil-quenching the mass of an alloy steel part (the alloy content having been necessary so that the part could be oil-quenched and thus

minimize distortion). If only the surface need be hard, the part can often be made of medium-carbon (0.40-0.70% C) unalloyed steel and the surface flame-hardened without distortion. Similarly, the use of nitrided alloy steel cylinder liners and similar parts can sometimes be dispensed with in favor of flame-hardened carbon steel.

Flame-hardening can often be credited with substantial saving in machining and grinding time, and therefore also with freeing machines for other uses. This is because flame-hardening can be applied to finished surfaces and subsequent machining to correct distortion, required for furnace hardening, is usually not necessary with flame-hardening.

Particularly for the hardening of only a few pieces of large size, surface hardening with the oxyacetylene flame can be done in much less time than furnace hardening.

Again, very large mechanical components that have worn too loose or ceased to be of serviceable dimensions may be machined down to smaller sized elements, and, if of flame-hardenable analysis, may be surface hardened to provide many additional production hours of usage. Or, their surfaces may be rebuilt to their original size, either by oxyacetylene or arc welding, employing welding rods or electrodes of flame-hardenable analysis. After machining to correct dimension, such areas may be surface hardened with the oxyacetylene flame.

Again, this process of oxyacetylene flame-hardening contributes to speeding up our defense manufacturing effort, in that it provides applications that readily fit into production lines, thereby eliminating the time lag incident to furnace hardening by the batch method. Flame-hardening stations fit themselves smoothly into the "line," receiving the part from the previous machining (or otherwise processing) station, surface hardening it mechanically or manually as required, and quickly releasing it for its next operation at the following station.

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Recently, it was found that induction heating applied to adapters for chemical shells, which in the past have been welded, gave a brazed joint that was superior and had less rejects. It was found, too, that induction brazing was performed in less time than welding.

—Ajax Electrothermic Corp.

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When hardening machined parts, scale and "soft skin" should be avoided. Cleaning and grinding both require extra time and expense. Production can be speeded and quality improved when tools, dies and production parts such as springs, stampings, wrenches, capscrews, etc. are bright-hardened in controlled atmospheres furnaces.

—Lindberg Engineering Co.

Gas Welding

by H. E. Rockefeller

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The Linde Air Products Co.,
New York

Today the rapid method of mechanized oxy-acetylene welding is being adopted to reduce costs, improve product quality, and increase production. The high speed at which production welding can be accomplished is particularly attractive today when national defense orders must be filled.

Mechanized oxy-acetylene welding is exceptionally suitable for high-speed production welding of light-gage material. Since oxy-acetylene welding itself is highly adaptable, a variety of setups and procedures can be devised for the work at hand. In one type of procedure the part is completely welded in one continuous operation. In another type of procedure the part is welded with a series of welds, or with two or more welds simultaneously made.

In the type of operation in which a continuous weld is made, such as in tube welding, the material is carried through the welding machine by a system of rolls and past a stationary welding blowpipe. Spacing of the edges to be welded can be changed by varying the pressure that the rolls exert, so that a gap can be maintained during preheat, and closed by proper location and pressure of the rolls during welding.

In the method in which several welds are made on each unit, the preformed stock is placed in a jig and rotated past a stationary blowpipe, or the jig and material may remain stationary while the welding head travels along the seam on a track.

This method is usually used in making vertical and girth seam welds on round or rectangular vessels. In some operations no welding rod is used, the edge being held in abutment. However, to obtain full-strength welds on materials of 12 gage and heavier, other than flat sheet, welding rod is used, and rod feed is automatic, controlled by a variable-speed mechanism.

Leakproof welds are economically made in gasoline tanks by mechanical welding.

Bronze-welding and bronze-surfacing on a production basis can also be mechanized. In both types of operation a volatile liquid flux is used to speed the operation.

In the assembly of a fan for a portable electric-drill motor, sheet stamping is bronze-welded to a machined hub. Average actual welding time is 3 seconds, and the production rate is 10 to 12 units per min. Also, in bronze-surfacing the lining of a rotary pump, metal can be deposited at the rate of 55 ins. per min. [A detailed description of bronze-welding operations appears elsewhere in this symposium.]

Tube Welding

An excellent example of mechanized oxy-acetylene welding can be given in a description of tube welding.

In this operation, coiled stock is fed into a roll-type forming machine with roll forms of a design to give the shape desired—such as rectangular, oval, or teardrop, all of which can be welded by this method. From the forming unit, the material passes to the welding unit which is usually close-coupled to the forming mill. The welding stand usually consists of at least two sets of horizontally and vertically adjustable, water-cooled side guide rolls. Preheating and welding take place between these two roll sets. With proper side-pressure control of these rolls, the weld reinforcement can be built up or reduced as desired on either the outside or inside, depending upon the use for which the tube is intended. Where perfectly flush inside and outside surfaces are desired, scarfing tools are employed to trim the weld.

After passing through the welding and scarfing stands, the tube is cooled in a water spray or bath, and sized and straightened in rolls provided for this purpose. Then it is cut off to length in an automatic unit that travels with the tube as the cut is being made and returns to its starting position.

In general, welding rates are limited only by such mechanical factors as those of cutting off and handling the material. With a recently developed machine, using a new-type multi-flame welding head, tubing can be oxy-acetylene welded at speeds ranging from 30 to 150 ft. per min., depending upon the thickness of material. Tubing of plain carbon cold-rolled and hot-rolled steels, stainless steel, and a wide variety of alloy steels can be produced with uniformly good quality welds at low production cost.

Installation costs for mechanized oxy-acetylene welding equipment are extremely low in comparison with other types of automatic welding equipment. Lower cleaning and maintenance costs and decreased reject losses usually make overall operating costs comparable to other automatic methods which are notably less adaptable to changing production methods. The welding speeds and shorter setup time of mechanized oxy-acetylene equipment are both responsible for the high-speed production, and with the properly designed heads available today, production rates are greater in many instances than those obtained with any other type of automatic welding equipment.

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Faster hardening of steel cutting dies (for textiles, paper, leather, etc.) in a 24 in. x 12. in. x 10-in. bench furnace was inexpensively achieved by eliminating the muffle and underfiring burners entirely. Precisely controlled direct radiant firing with gas from above made the conversion possible without sacrificing atmosphere control. Greater production speed resulted from larger working space (allowing heavier loading) and from more rapid heat transfer —as well as from the elimination of the heat-load represented by the removed muffle.

—Selas Company

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Arc Welding

by C. J. Gallant

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North American Aviation, Inc.,
Inglewood, Cal.

Arc welding as a production facility is not new with aircraft manufacturers but the development of adequate control and technique which would insure the producing of articles with a saving in manufacturing hours and yet conforming to Army, Navy and commercial specifications (primarily dictated by years of field experience) is quite recent.

Several manufacturers of welding generators offer the prerequisites of an acceptable aircraft equipment, viz., a machine characterized by inherent arc stability, high rate of recovery, ease of striking or starting the arc and arc control. Accessory equipment is available which will eliminate craters normally present in weld endings, and welding rods and coatings have been developed which have considerably reduced the possibility of rejection. It is obvious that rods, rod coatings, generators, and accessory equipment available to the manufacturer in quantity, are but compromises of the perfect articles but nevertheless, the best of these will give entirely satisfactory results.

Having available trained personnel and suitable generators and rods to produce optimum arc welding under a given set of conditions it is suggested that the following be given careful consideration since experience has shown that through proper design, selection, or elimination (whichever is applicable) of these items considerable decrease in man-hours and rejections is possible: (1) Joint design, (2)

Fig. 1. *Cross section of X4130 steel arc welded. Macrographs A, B and C, without crater eliminator. Macrographs D and E, with crater eliminator.*

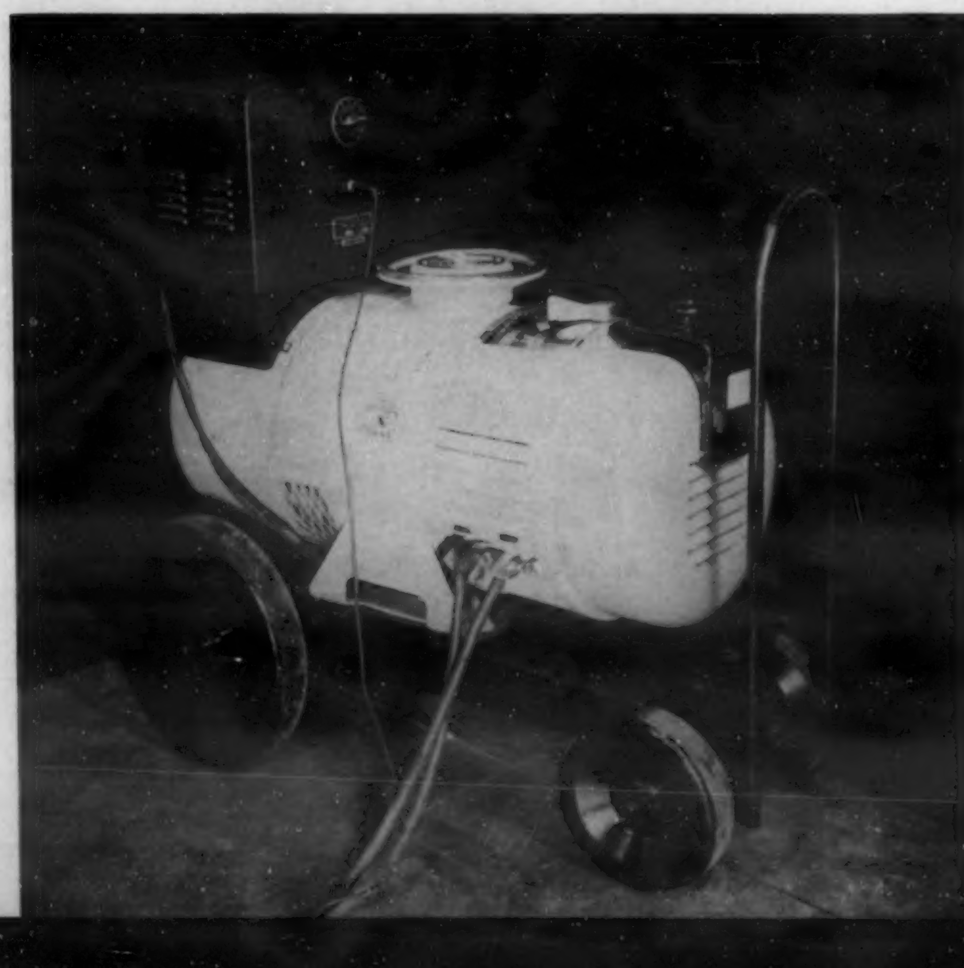
Crater elimination, (3) Accessory equipment, (4) Jig and fixture design, and (5) Flow of parts.

1. *Joint Design:* Much has been said relative to joint design both with respect to accessibility in laying the bead and with regard to minimizing the amount of deposited metal for a given joint. It has been found, however, that too much stress has been placed on the "amount of welding" and too little on "joint accessibility." In the majority of cases an accessible joint although so designed at the expense of additional weld length will yield a reduction in welding time, and is therefore recommended.

2. *Crater Elimination:* Craters normally present in all weld endings are the result of abruptly stopping the arc. Obviously this condition is not tolerable in aircraft primary structures and especially those structures subject to high fatigue stresses, and is therefore an ever-present cause for rejection. Fig. 1 illustrates surface and sub-surface craters, and also similar photomacrographs typical of the type of ending (consistently free from this condition) when using the Stroco Crater Eliminator which can be adopted to all standard generators. This equipment, remotely controlled either by means of foot operated normally open contacts or by a thumb operated push button made integral with electrode holder, insures correct diminution of welding current as the end of the weld run is approached, and its effects are in contra-distinction to such practices as wiping or lengthening of the arc or any other method resulting in an abrupt stoppage of the welding current.

3. *Accessory Equipment:* Low current stations, remotely controlled field rheostats, crater eliminators, etc. which increase the flexibility or facility of the generator without seriously impairing arc stability, striking characteristics, etc., provide the welder with additional safe tools such that more of his time can be productively employed with little or no increase in fatigue. Such equipment has been found to be

Fig. 2. Wilson hornet welding generator with Stroco crater eliminator.



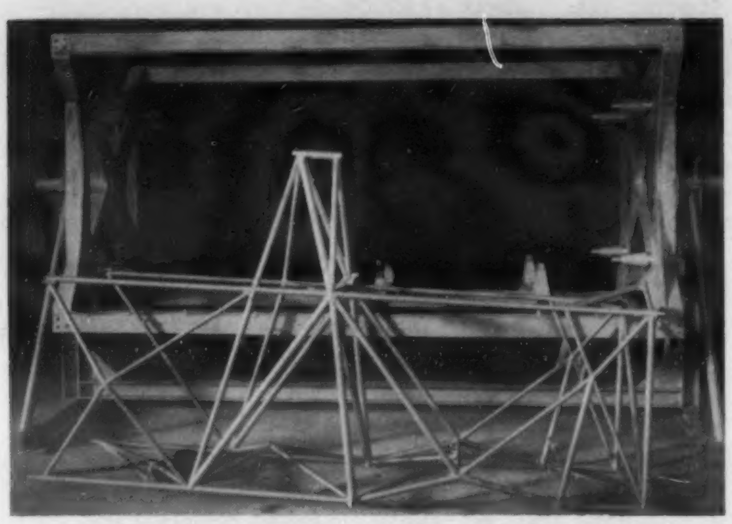


Fig. 3. Box frame jig.

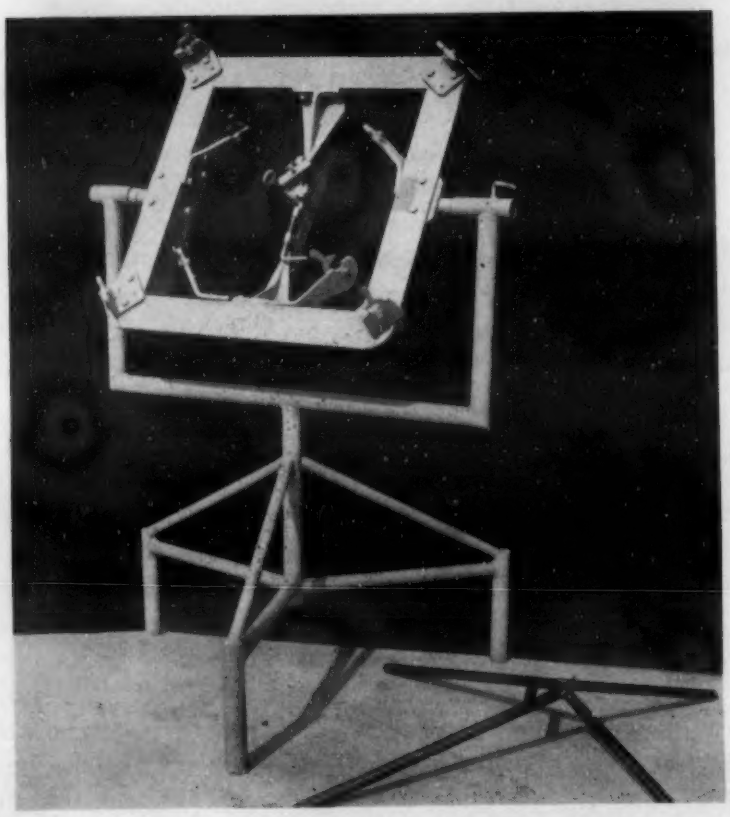


Fig. 4. Rotatable jig.

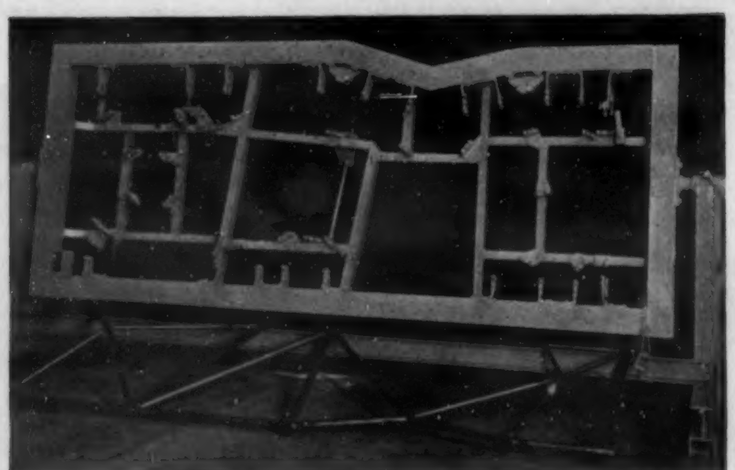


Fig. 5. Box frame jig (Trainer).

particularly advantageous when the welder is working on large box jigs or in relatively congested quarters. Fig. 2 illustrates a Wilson Hornet aircraft welding generator with Stroco Crater Eliminator.

4. *Jig and Fixture Design:* Considerable thought to the design of jigs and fixtures will be well repaid. Jig tolerances and rigidity are obviously mandatory. These qualifications, however, do not limit jig and fixture design to cumbersome, immobile units. Jigs, rotatable about one axis at least are recommended. This type design will allow the welder to accomplish the majority of his work without necessity of readjusting either himself or his equipment, and will further obviate considerable up-hand and overhead welding. It is not always practical to so design jigs or fixtures, but in the case of trainers of welded tube construction it appears that only one jig, excepting those jigs which fall under the category of fittings and other minor parts, should from practical considerations be non-rotatable, viz., the box frame jig (Fig. 3) in which final assembly of the various components is made. Fig. 4 and 5 illustrate rotatable jigs.

5. *Flow of Parts:* Considerable time saving has been effected by alleviating congestion which normally occurs on both sub-assembly and final assembly jigs whereon parts usually are hand fitted prior to welding. In such cases congestion or loss of welding time results due to disproportionate number of metal fitters and welders engaged on the jig for the allowable space. These conditions have been eliminated by (1) the addition of assembly jigs whereby set-ups can be completed before welders take over, and (2) in certain cases by the addition of set-up jigs on which sub-assemblies are fitted before being transferred to the next assembly position.

Resistance Welding

by R. T. Gillette

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General Electric Co.,
Schenectady, N. Y.

The use of resistance welding in its many phases can do a great deal to increase production and lower costs when properly applied.

The best equipment available should be purchased, as a great many pieces of welding equipment in use are obsolete and there is no economy in using obsolete welders.

The application of welding requires competent supervision and operators, proper maintenance of equipment, and careful preparation and cleaning of parts, if satisfactory results are to be expected. A few resistance welding application possibilities follow:

The end shield and bearing on a very small motor

were made from a drop forging of brass which had to be subsequently machined for the outside fit of shield and the bearing bore, both expensive operations. This end shield was changed to a mild steel part made in a punch press and a brass bearing made on a screw machine.

This brass bearing was machined with an annular projection and the projection welded to the steel end shield with one subsequent machining operation. This was a much faster operation, replaced a considerable poundage of brass with mild steel, made a substantial saving and in no way affected the quality of the part.

The use of high speed steel in tool bits may be conserved by flash welding a piece of SAE-1010 or SAE-1020 or other low carbon steel to the end of the high speed tool bit when it becomes too short to clamp properly in tool post or holder. (See Fig. 1.) In order to make a satisfactory weld in this type of material, a few simple precautions are necessary. As the high speed steel has higher electrical resistance than the low carbon steel, the amount protruding from the welder clamps should be in the ratio of two to three, the low carbon steel the greater amount to give the proper heat balance.

After flash welding, the welder clamps should be opened to a larger spacing than used for welding and the power input reduced somewhat and the joint reheated until the color of the steel at the joint becomes a dark blue; then immediately placed in a container of powdered lime or other material to retard cooling and left in this material until the tools come to room temperature. The flash is then ground off and the tool is ready for further use. The same method may be used to repair drills which have had the tang broken off.

Where long straight rows of spot welds have to be made, of which Fig. 2 is an example, they may be made much faster by the use of a seam welder. Where obstructions are encountered, as shown by the header in part shown on Fig. 2, a start may be made close to the header by the use of notched wheels as shown in Fig. 3. These wheels should be large enough so that a complete row of welds may be made without the row of welds exceeding in length the circumference of the wheel. If the wheels are less in circumference than the length of the row of spot welds, a second start may be made on the work piece. These notched wheels are mounted with cables and weights around their shafts so they automatically return to their starting point when the clutch and pressure is released.

Where straight pieces are to be welded with no obstructions, plain wheels with no notches are used and the return devices omitted. With this set-up there is no limit to the length of the parts which can be welded.

Where comparatively thin material is to be welded in long rows of spot welds, multiple wheels as

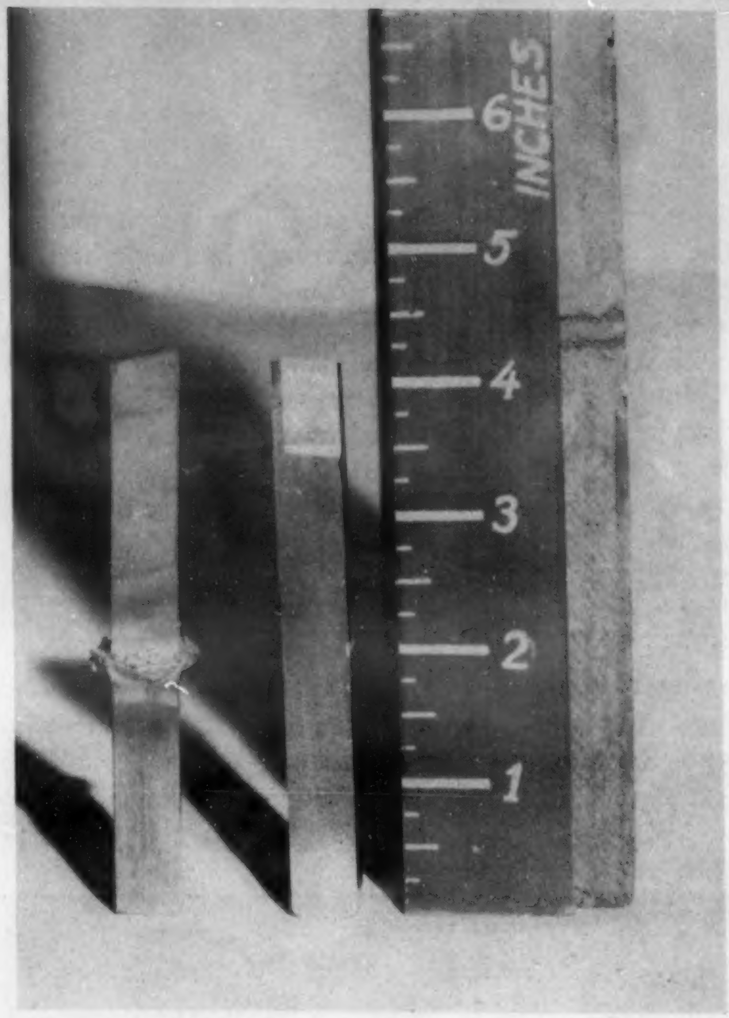


Fig. 1.

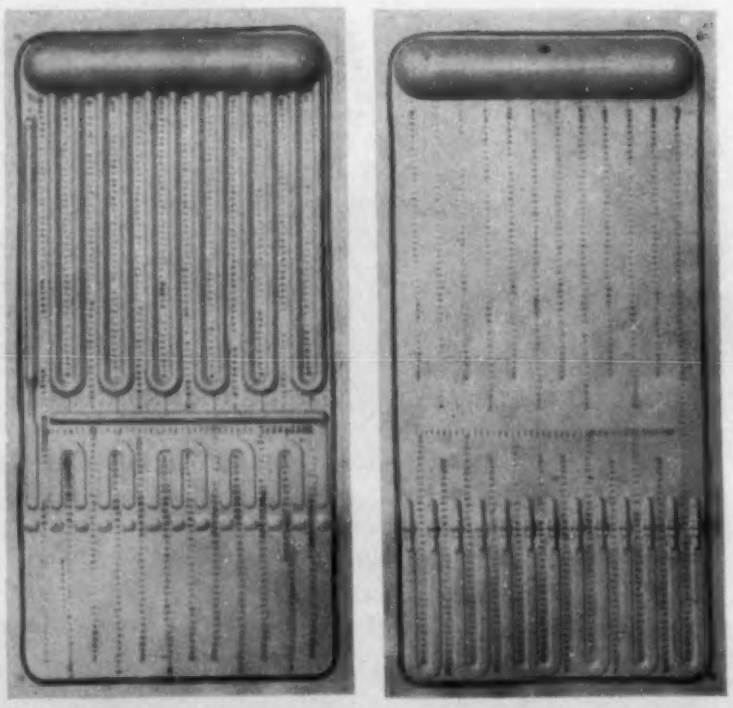
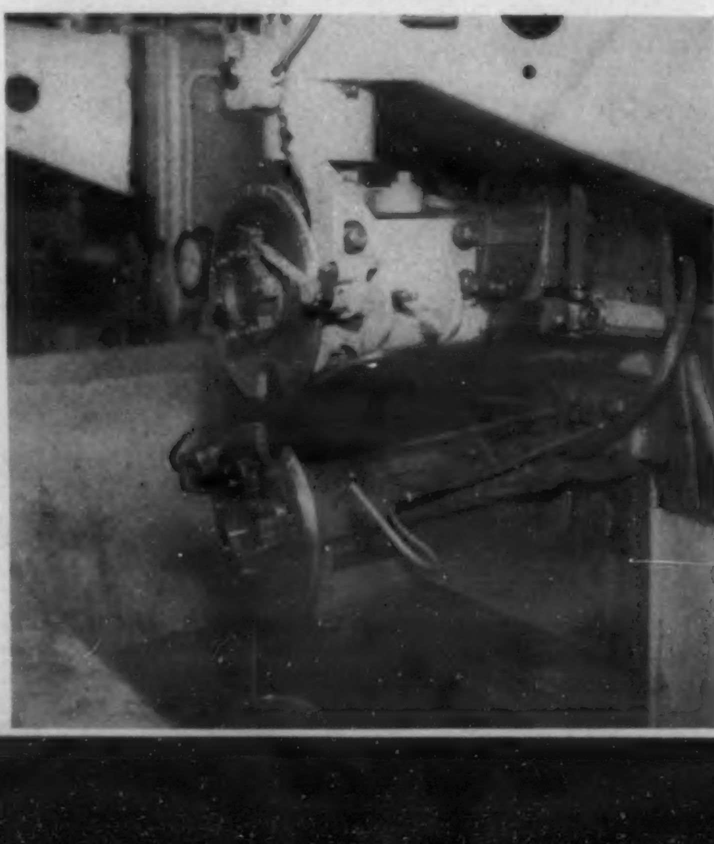


Fig. 2.

Fig. 3.



shown in Fig. 4 may be used. In this case, welds are made in series with a backing bar underneath, with a welding transformer connected directly across two wheels. Machines of this type have been built with as many as ten wheels and five transformers.

In the case of all of these seam welders making spot welds, the best method of spacing the welds is by the use of electronic control. (Fig. 5). With this, by using a pre-determined speed of wheel or work travel and setting enough "on time" on the electronic control to make a satisfactory spot, then setting the "off time" to give the spacing between spots which is required, correct spacing is obtained. This may easily be figured out; using inches per minute of travel time with the frequency of the circuit divided into "on time" and "off time" will give the number of spots per minute. As an example, with a wheel or work travel of 100 in. per min. with 4 cycles on and 6 cycles off, and the use of 60 cycle power, you would have 6 plus 4 which is 10 cycles, divided into 3600 cycles per min. or 360 welds per 100 in., or between 3 and 4 spots per in. If this were changed to 4 cycles on and 32 cycles off, we would have a total of 100 spots or a spot each inch.

Fig. 4.

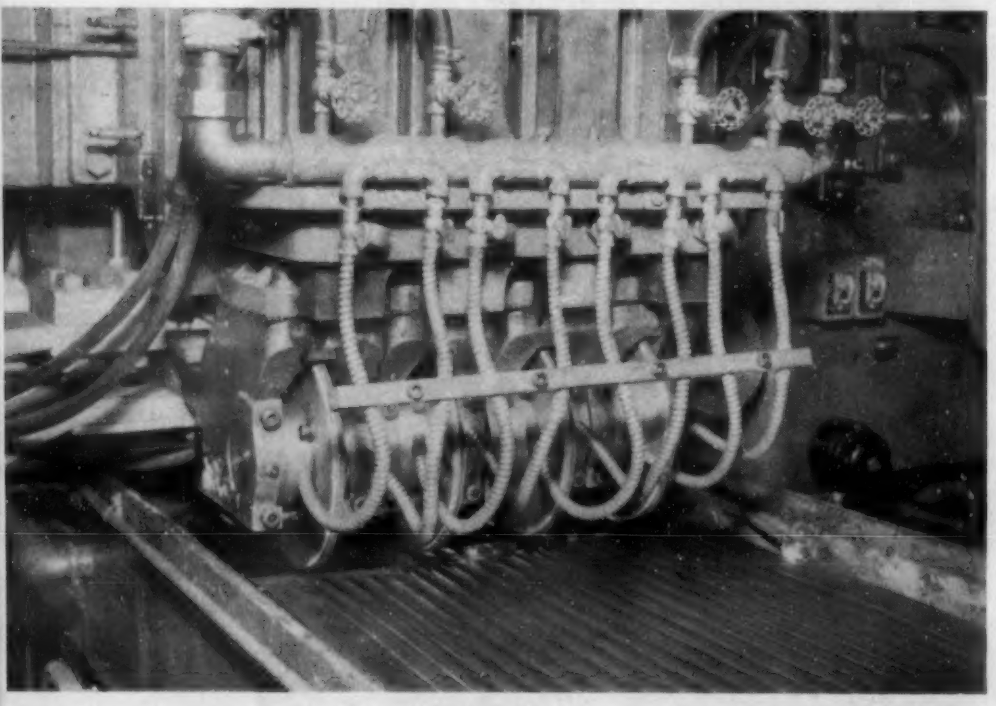
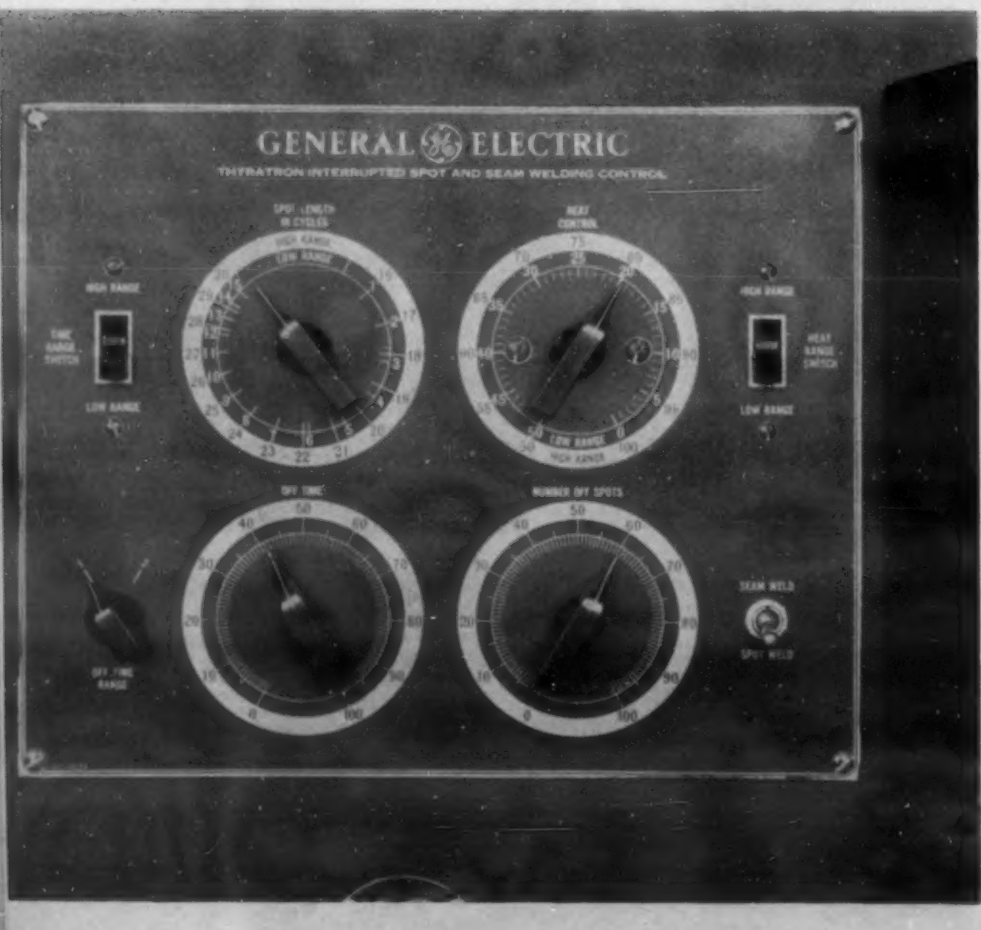


Fig. 5.



The use of electronic control for this type of welding is much to be desired due to its accuracy and flexibility. It is also advisable to use this type of control for most spot and seam welding jobs. In welding heavy material, the use of pulsation welding is of considerable advantage.

When a large amount of production of a particular part is to be made, a special equipment for this job should be considered, as many times special equipment can be built which will do several operations without moving the work piece from one piece of welding equipment to another. Among other pieces of equipment of this character might be mentioned the multiple electrode hydraulically operated spot welders which may have as many welding points as desired to complete a job, and the mounting for the points, and the points themselves act as a jigging member of fixture for the proper location of the parts for a complete assembly.

There are a great many possible combinations of various types of resistance welding equipment which closely follow machine tool practice which cannot be covered in an article of this character. Information on this type of equipment may be secured through the offices of the Resistance Welding Machine Manufacturer's Association or any of its members.

Metal Cleaning

by R. W. Mitchell

Technical Director, Magnus Chemical Co., Garwood, N. J.

Defense production and the general manufacturing that stands behind it involve a great many metal products which require cleaning at various stages in their manufacture. Therefore, it is quite essential that these cleaning operations be speeded up wherever possible in order not to become a constriction in the flow of production.

Cleaning problems vary considerably and no blanket recommendations can be made to cover all of them. However, a general survey of the various cleaning methods and then a description and explanation of one relatively recent metal cleaning method with examples of its application, might give some helpful hints for hastening the cleaning operation.

There are two general types of cleaning solutions used to prepare metal parts for the finishing processes. One is an aqueous solution and the other is

a solvent either in liquid or vapor phase.

Aqueous solutions require one of the following methods of handling: Tanks where the work may be given a dip, swash or soak; an electric cleaner; a washing machine; or a steam gun or vapor cleaning outfit.

Solvent cleaning consists of soaking in, or wiping with solvents such as gasoline, naphtha, carbon tetrachloride, etc. This practice is not always the most satisfactory from the angles of safety, economy and quality of results. The development of "degreasers" has made solvent cleaning much more practicable. In degreasing, the cold work is hung in a vapor of the chlorinated solvent above its boiling solvent. Solid-particle-dirt, pigment, lint, metal particles, etc. are not completely removed by this treatment, however.

By combining some of the desirable features of solvent cleaning at low cost, with the good features of cleaning by means of water solutions we get a method which is rapid, economical and shows good results in many applications.

The method, known as the "emulso-dip" process, involves a pre-cleaning operation which removes the surface dirt, and a secondary dip in a metal cleaning solution if a chemically clean surface is desired. In many cases, the second operation is not needed.

The "pre-cleaning" solution is made by dissolving 1 lb. of a precleaning solvent—an oil soluble wetting and emulsifying agent—to a gallon of kerosene. This solution is either used in a large tank where the pieces to be cleaned are dipped, or the uncleaned parts are sprayed. The solution may be cold ordinarily, but penetration is more rapid if warmed to 120 deg. F. This solution penetrates and loosens all oil and dirt deposits, as well as bonded metal particles, from the metal, and puts all impurities into a non-adherent condition.

Following the dipping operation, which takes from 30 sec. to 3 mins., pieces are drained for about ½ min. and then flushed with cold water from a pressure spray. The water emulsifies the solution and washes away all the dirt with the emulsion. The surfaces of the cleaned parts are now *physically* clean; that is, amply clean for painting, lacquering, inspection, assembly and similar finishing operations. If a *chemically* clean surface is desired for plating or vitreous enameling, the parts must be subjected to the second stage of immersion in an alkaline metal cleaning solution.

The solvent emulsion cleaning process has already found useful application in the cleaning of such work as drawn metal parts, especially in those cases where pigmented drawing compounds have been used, in the removal of polishing and buffing compounds, and in the removal of certain sulphurized or chlorinated oils which are difficult to remove by normal washing procedures.

One company, seeking the fastest possible production, found the process neatly adaptable to an automatic set-up for the cleaning of lighting fixtures (which embraced several metals such as steel, copper, brass, aluminum and zinc die-castings) to remove both machining and drawing oils and buffing compounds, before plating.

Another installation where the "emulso-dip" process has proved highly successful is in the cleaning of tempering oil from flat and coil springs. Here the springs are placed in wire baskets and soaked for 3 to 5 mins. in a steel tank containing the pre-cleaning solvent. The baskets are removed and allowed to drain to minimize loss by drag-out of the solvent. After this, the baskets are put on a slat rack over a drain and thoroughly pressure-spray-rinsed with tap water. They are then immersed for a couple minutes in a clean boiling rinse where the springs pick up sufficient heat to make them self-drying. After removal from the rinse they are blown off with compressed air and allowed to dry.

Large steel sheets, which often present a difficult cleaning job due to their large size, can be cleaned quickly and efficiently by applying the "pre-cleaning" solvent as a spray to the surfaces, and then flushing them off with cold water spray at as high a pressure as possible—up to 100 lbs. Care should be taken to remove the rinse unit at sufficient distance from the first spray unit so that no water will get back into the "pre-cleaning" solution. The presence of small amounts of water in this solution curdle it and greatly impair its action.

To expedite drying a vertical row of compressed air jets on each side of the plate can be used to blow off the rinse water before going into the dryer.

This plate cleaning method can be easily conveyorized and thus provide an even more rapid metal cleaning system, which gives good results.

★ ★ ★

Many manufacturers of defense materials are speeding up production and conserving power through use of alternating-current arc welders instead of direct-current arc welders. By avoiding magnetic disturbance, a-c welders permit the use of larger electrodes, with the result that over-all welding time is reduced as much as 25 to 40 per cent on some types of commonly used joints.

—*General Electric Co.*

★ ★ ★

Atomic-hydrogen arc welding equipment is reported to be speeding the production of aluminum boxes vital to defense. The intense heat developed by this equipment allows welding to be done more rapidly than by other processes. Troublesome distortion is also avoided by the concentrated high temperature of the atomic hydrogen arc.

—*General Electric Co.*

Hot-Dip Galvanizing

by Wallace G. Imhoff

*President, Wallace G. Imhoff Co.,
Vineland, N. J. and
Technical Director of Research,
American Hot-Dip Galvanizers Assoc., Inc.,
Pittsburgh*

There are two things that will greatly increase production in hot-dip galvanizing if studied carefully. These two operations are: (1) Pickling, and (2) Fluxing. As a direct result of the proper conditions of pickling and fluxing we may expect a faster speed through the bath, and as a direct result of proper fluxing technique, we may expect fewer seconds and work that has to be done over. The net result therefore of establishing the correct pickling and fluxing is *to greatly increase production.*

Both of these operating conditions appear to be old subjects discussed many times in the technical literature. That may be true, but at this time it will be pointed out how these specific results can be accomplished.

Correct Pickling Practice

There are four distinct factors to be considered in determining the correct pickling practice. These are —(1) The acid strength of the bath; (2) The iron content of the bath; (3) The bath temperature; and (4) The kind of base metal pickled. Abominable pickling fumes, boiling acid, and high acid strength, all indicate that the pickling conditions are wrong. The pickle capacity is too small, and there are not enough pickling tanks for production requirements.

The correct pickling conditions for the production desired are to be found when there are no fumes, when the acid strength is around 4 percent, and when production requirements are easily taken care of with the tank capacity. Definite control of pickling operations, and the correct pickling conditions may be found by accurately controlling pickling operations. This is done with quick test tablets or other methods of quickly and accurately determining the acid and iron content of the bath to keep it at the best pickling condition for the base metal being pickled. A stainless steel cup case thermometer should be used to take the bath temperature every time a quick test is made for acid and iron content of the bath. Thus the correct pickling time is established; the right acid strength to do the pickling right and in the shortest time; and finally a standard pickling practice is established for each article.

Production in hot-dip galvanizing depends absolutely on whether the article is properly pickled. Surfaces that are not properly pickled slow down production, cause an increase of bath temperature, require a longer submersion time, and waste zinc by taking on an excessive metal deposit. *Correct pickling practice speeds production, and eliminates seconds and work that has to be done over.*

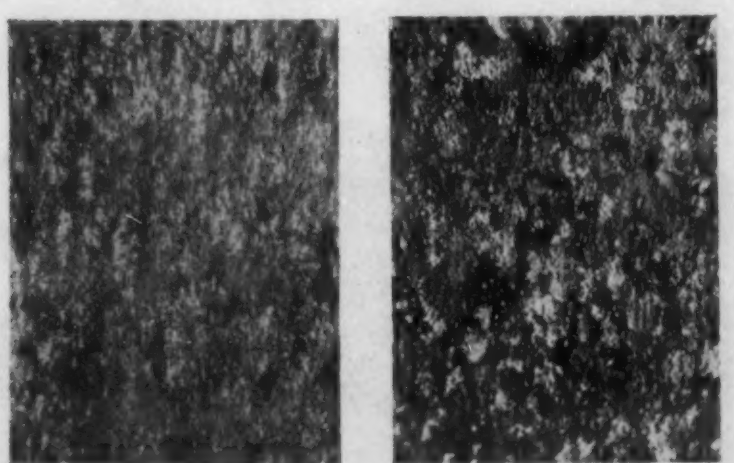
Correct Fluxing Practice

The modern fluxing practice of using a liquid flux not only speeds production, but it actually increases production by eliminating seconds and work that has to be done over, in addition to speeding up the normal travel through the bath.

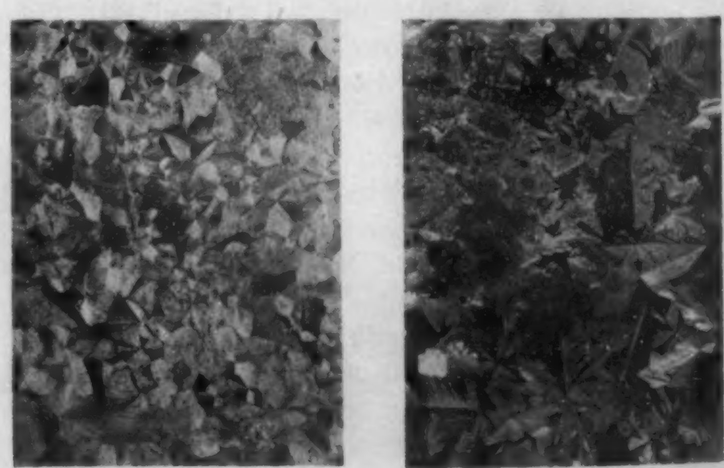
The old fluxing technique uses muriatic acid as a dip, and in many cases the articles are dried. This takes time, and in addition it is almost impossible to dry an article without again depositing corrosion on the surface. The new liquid fluxing technique replaces the muriatic acid dip with a dip of zinc-ammonium chloride, and then passes the article down through a slag flux of sal-ammoniac and zinc-ammonium chloride on the surface of the galvanizing bath.

Attention is called to the fact that the clean pickled and washed surface of the article when dipped into the liquid flux solution carries a complete film of liquid flux on and above every particle of the iron surface. In addition to this the liquid flux will easily run into the seams, crevices, corners, etc. of

Correct pickling practice (left). "Over-pickled," "burned" incorrect pickling practice (right).



No flux spots, correct fluxing practice (left). Flux spots (left center), incorrect fluxing practice.



the article fluxing down in these more difficult places which are usually the trouble makers of the old muriatic acid fluxing technique. The old method also calls for the throwing of a handful of sal-ammoniac inside tanks to help secure a good coating contact. It does this sometimes, but most of the time it is a very ineffective method of helping the flux to operate. The liquid flux flows readily to all corners and difficult spots, and in addition to its excellent fluxing qualities, it actually stops corrosion in case the article must wait its turn in the air to be galvanized. The change therefore that may be expected from this new fluxing practice is—(1) A decided speed up of production; (2) An increase of production because there are almost no seconds made; (3) an actual reduction of galvanizing costs, even though the first cost price of the zinc-ammonium chloride is more than the muriatic acid.

Summary

Thus to speed up production in hot-dip galvanizing for defense the following definite things must be done—

Pickling: Accurately control pickling operations with a quick test pickling outfit consisting of tablets for testing the acid content of the bath; for testing the iron content of the bath; and also take the bath temperature when these tests are made. Determine the correct pickling practice for the base metal being pickled. Good pickling practice is an acid content of about 4%; empty tanks at 8% iron content of bath; use a bath temperature of 140 to 160 degrees F. All productions can be done without fumes when the pickling capacity is large enough, and the tanks are big enough. Fumes and bad pickling conditions indicate the need of more tanks, and perhaps larger tanks.

Fluxing: Introduce the liquid fluxing practice of a solution of zinc-ammonium chloride at about 180 degrees F. The saturation of the bath and the temperature must be determined for the kind of work being galvanized. The liquid flux gives faster speed, and also fewer seconds and defects because of the improved fluxing conditions. The first cost of zinc-ammonium chloride is more than muriatic acid, but the increased production and higher quality product, together with much better operating conditions offset this higher first cost, and in the end give a net cost lower than the old method.

★ ★ ★

Production of furnace-brazed track links for tanks has been speeded up by employing combination roller-hearth type electric furnaces for brazing, cooling and re-heating for quenching. The links are loaded on a tray on the charging table, then the end door is opened, the tray is pushed in, and the door is closed. The driven conveyor carries the work continuously through the three chambers, thus eliminating intermediate handling. Trays are pulled out intermittently at the discharge end, and the links are lifted off and quenched in oil. Thus, the brazing and handling is accomplished in essentially one operation.

—General Electric Co.

Blast Cleaning

by C. A. Snyder

American Foundry Equipment Co., Mishawaka, Ind.

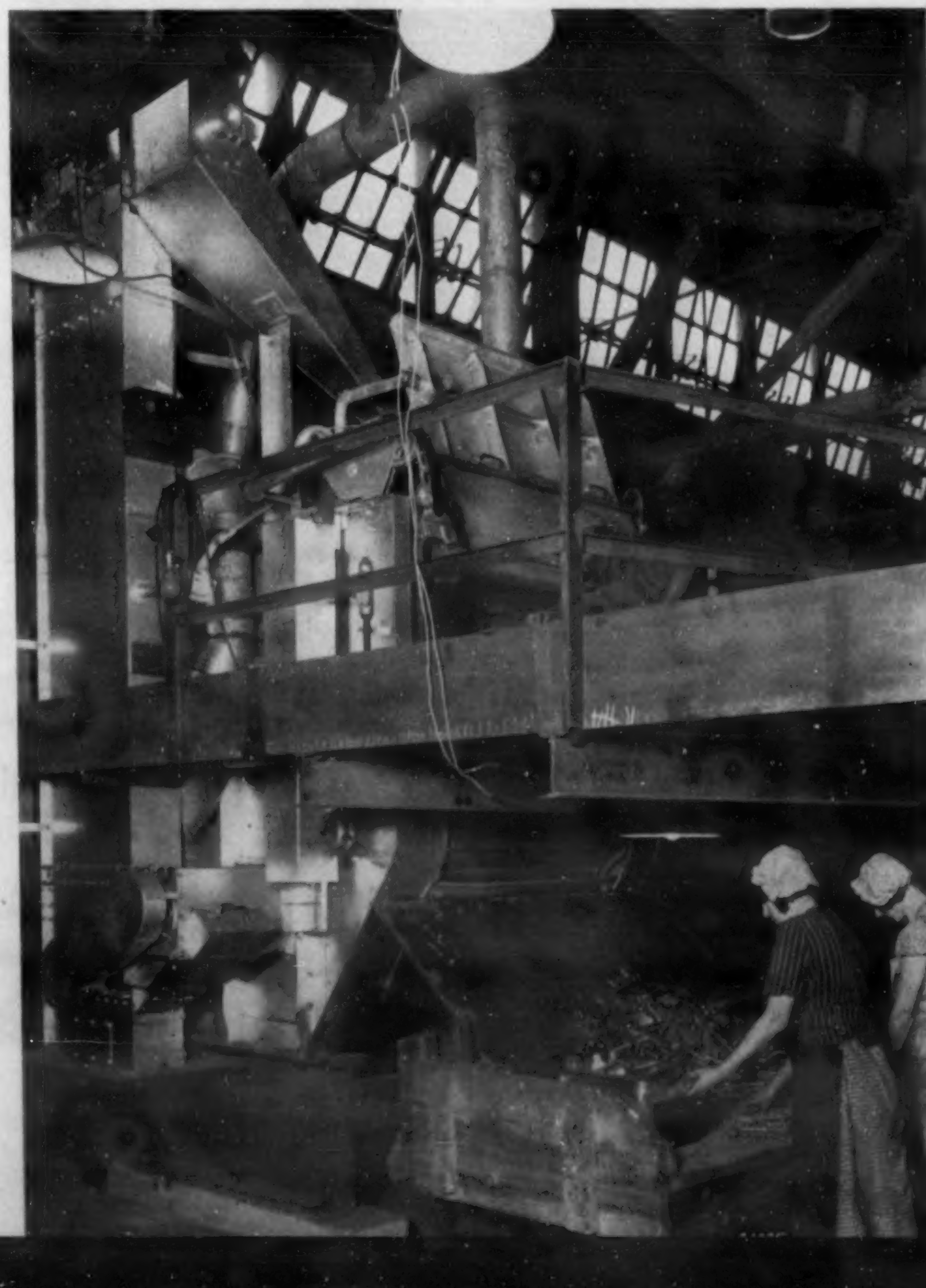
Metal cleaning by either airless or pressure blast method carries a tremendous responsibility in the successful fruition of the Defense Program.

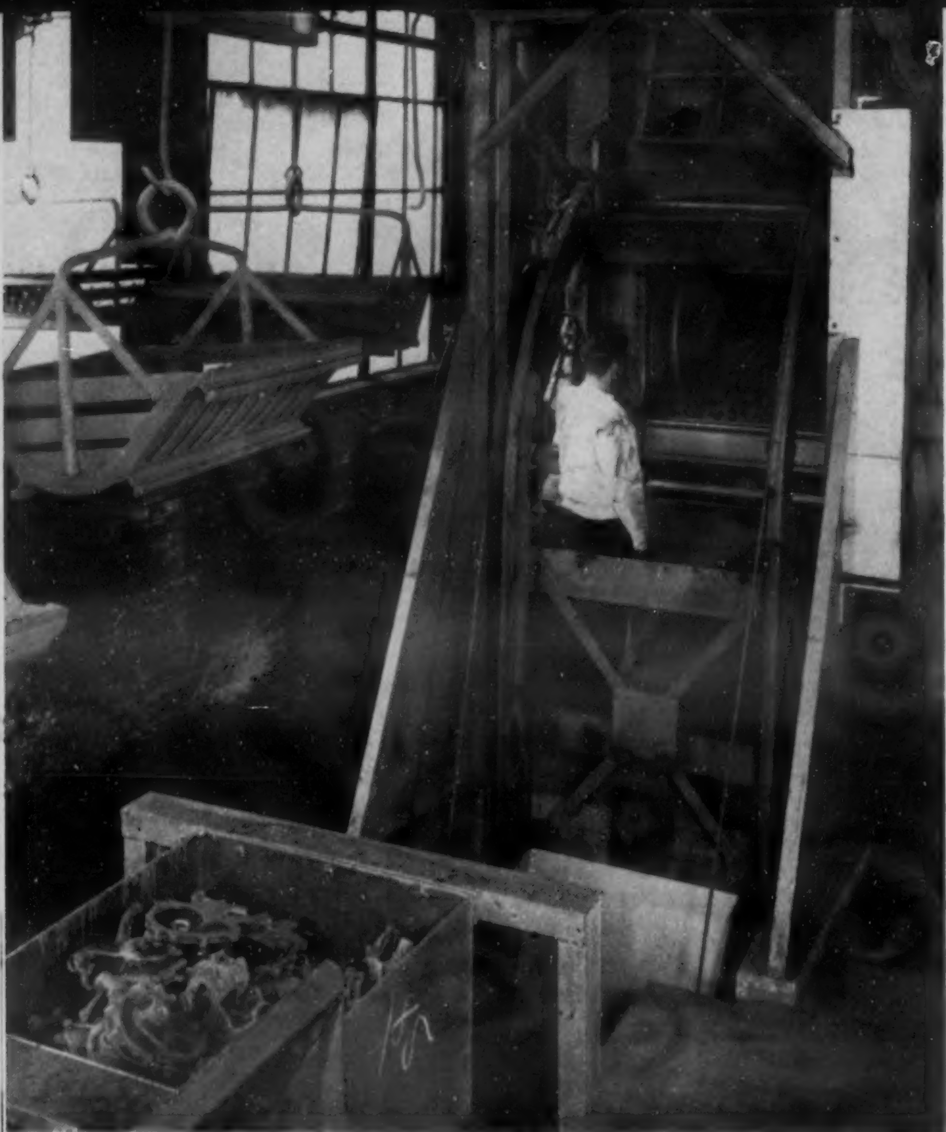
Aside from greatly increased general cleaning needs under the program, blast cleaning is used for such specific defense work as the cleaning of shells, bombs, armament, tank tractor treads, machine gun cartridge clips, rifle and gun barrels, aircraft engine cylinders and parts.

With the production of many of these items running into the millions, it is obvious that the cleaning process cannot be permitted to choke the flow of work at any point in the manufacturing process. The following are several practical ways by which this can be accomplished:

1. The ventilating factor is a point that is oftentimes overlooked in seeking to improve blast cleaning efficiency, but it is a point of highest importance. Useless fines must be removed from the cleaning chamber by proper ventilation, otherwise the blasting action is retarded; the cleaning agent, whether it be abrasive or sand, does not have a chance to do its best work; and oftentimes the failure to remove foreign matter from the cleaning chamber results in the deposit of a smudge upon the work.

A 48-in. by 42-in. wheelabrator tumblast installed at Link Belt Co., Indianapolis.





Another tumblast, with loader and operator, showing conveyor and sorting mechanism for loading machine.

Keeping abrasive clean by proper ventilation is especially important when metallic shot and grit are used. In abrasive blasting, sand, scale and fines have been known to retard cleaning speed as much as 50 per cent; and surprisingly enough they greatly increase wear on parts.

2. Some modern blast cleaning machines do their work so quickly that it is advisable to use a timer to prevent over-blasting and under-blasting. Not only does the timer help to cut wasted minutes from the daily schedule, but it also prevents wasted power and abrasive; reduces wear and maintenance; permits the operator to busy himself with other things without losing time in inspecting the load unduly; and prevents the problem of undersized parts on jobs that must be kept at close tolerances.

3. In selecting your cleaning equipment make sure that the process does a thorough job of removing sand and scale right down to the virgin metal. An efficient cleaning process does wonders in improving, speeding up, and economizing on many subsequent operations: For example, it will help you to improve the grinding and machining of your work; it will increase tool life; it will simplify inspection; and it will help you to obtain a true hardness reading whenever that is necessary.

4. Loading, unloading and conveying of material to and from the machine can be serious offenders when it comes to wasted time. Ingenious devices have been designed and built by many plants right in their own shop to improve these operations. In some cases the equipment manufacturer can be of great assistance in designing or supplying mechanical devices for these jobs. A loader is desirable in most cases because it permits charging the machine almost instantly after a previous load has been discharged.

5. Make sure that the abrasive used in your machine is of the proper size and type for your work. You can determine this only by actual test, but it will certainly pay dividends in improved cleaning and operating efficiency.

Selection of Heat-Treating Furnaces

by A. H. Vaughan

Chief Engineer,
The Electric Furnace Co.,
Salem, Ohio

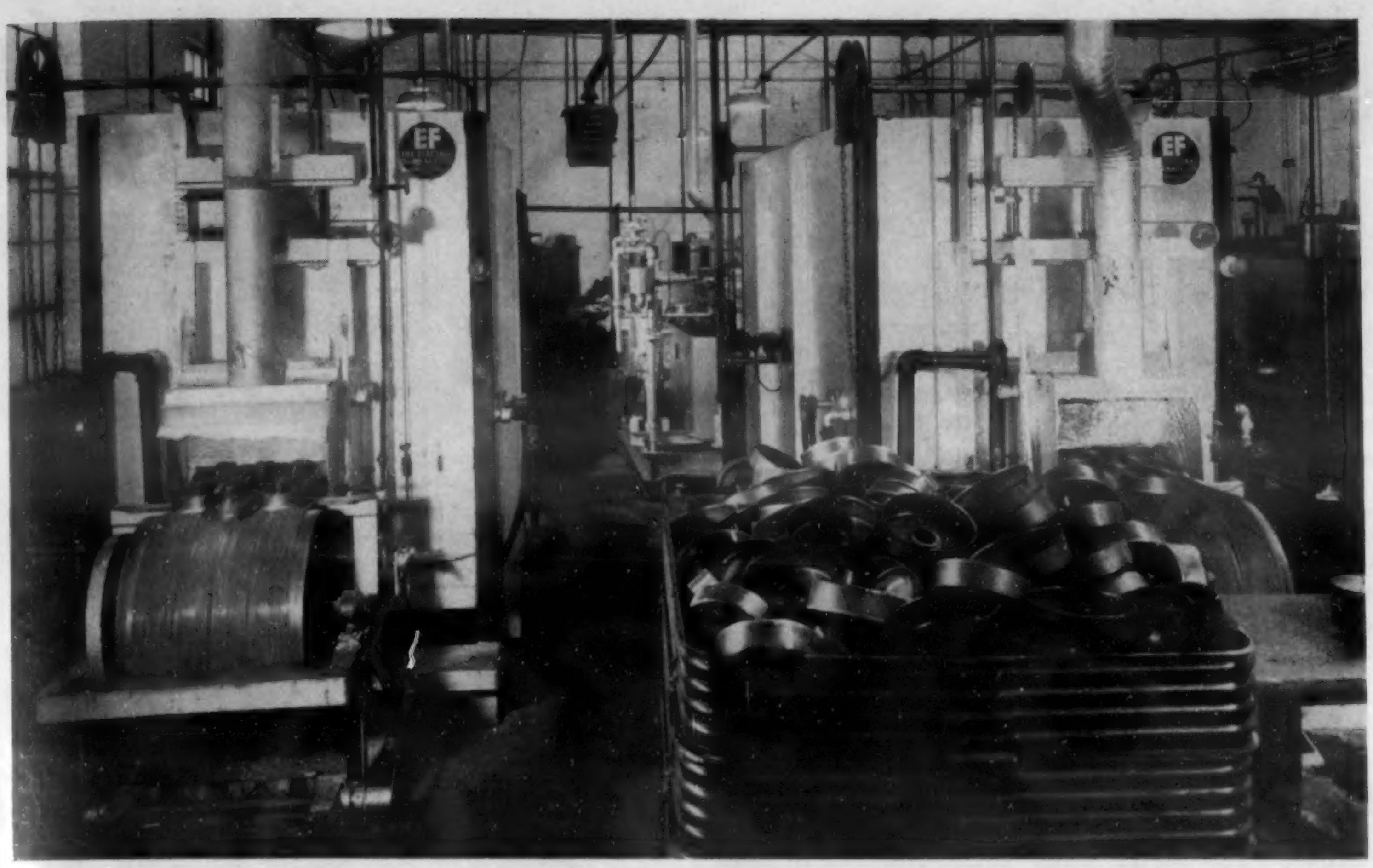
Heat-treating furnaces of production size are in most cases either custom built or of completely new design. This is a natural result of the great number of different heat-treating processes, the variety of parts treated, and preferred methods of handling material. It is, therefore, obvious that the furnace builders greatest problem in the present emergency is to do the required amount of engineering in the time available.

Wherever possible, existing furnace designs should be used. Many types developed and widely used in peacetime industry are equally well adapted to defense production. An example is the "chain belt conveyor" hardening furnace illustrated. Such furnaces handle aircraft engine parts, machine gun cartridge clips, and similar work as well as the bearing races, bolts and screws for which they were originally designed. They can be operated with special atmospheres where needed.

Numerous other types are similarly useful. The time needed to place these furnaces in service depends only on the speed with which parts can be fabricated and control apparatus obtained. Their performance has been tested in actual service. A final consideration of no small importance is that they still will be useful when normal conditions return.

There is, of course, a point beyond which new design becomes unavoidable. Even here, however, much time and effort can be saved by making the maximum use of existing design. Often only a new size is needed and in it can be incorporated many standard parts without change. The furnace builder may in some cases be able to produce a unit closely patterned after previous designs without appreciable loss of time because with care and a modicum of forethought, material purchases can be made and work started before the complete details are worked out.

Finally, the purpose of these savings is to leave open the necessary engineering capacity for equipment which must be of distinctly new character. There are enough cases of this kind to absorb all the ingenuity we can muster. A high order of precision is generally demanded, and the work often requires careful study from the standpoint of conveying and handling apparatus. New developments in the special atmosphere field are frequently so advantageous that they cannot be disregarded. Not infrequently, a process such as copper brazing makes



Charging end of two copper brazing furnaces with continuous mesh belt conveyors. These units will handle any size or shape of assembly up to 10 in. high by 18 in. wide and most any length.

possible great improvement of a product or great simplification in its manufacture, and such an opportunity should be capitalized to the utmost.

It is certain that flexibility will be indispensable. We cannot forsee what radical changes will be necessary in the design or manufacture of arms; but we can use care to select furnaces which have the versatility to meet the new demands.

★ ★ ★

To avoid unnecessary loss of time in carburizing, keep your carburizer in production condition. Aeration rejuvenates the carburizer. Removing non-usables such as dust and ashes eliminates insulation of the container and allows the heat to penetrate faster. Both of these results are accomplished by using a screening machine, which effectively and speedily keeps the carburizer producing.

—Thurner Engineering Co.

★ ★ ★

Infra-red lamps can be used for rapid drying in many metal finishing operations with a great saving in time. The lamps are used to best advantage in handling work on a continuous conveyor system basis, instead of in the "batch" system. Infra-red lamps are suitable for drying, baking or dehydrating applications.

—Wabash Appliance Co.

Blackening Steel Parts

by G. W. Pressell

Executive Vice President, E. F. Houghton & Co., Philadelphia

With Defense production taking a heavy toll of plating materials such as cadmium, zinc, nickel and chromium, industry is turning to other methods for protection and beautification of metal surfaces. By blackening, for example, instead of plating, faster production is obtained not only through the avoidance of delay in procuring raw materials, but by reduced processing time.

The blackening process is essentially a controlled oxidation. By immersing parts in a highly alkaline solution maintained at boiling point (290-295 deg. F.) a black oxide coating is uniformly produced on the surface of the steel.

This coating serves to retard rust or corrosion, and also beautifies the part by the lustrous black finish produced. It does not change dimensional sizes and its cost is far less and production is much faster than with the protective coatings produced by most electrolytic processes.

Faster production in the blackening process itself is obtained by efficient handling methods. Naturally, the longer parts are immersed in the blackening bath the better will be the protection accorded by the surface coating of oxide. While it is possible to get

a satisfactory coating from an appearance standpoint in a short time, more complete protection is provided by periods of immersion from 9 to 15 min. Therefore, rapid production cycles of 5 to 7 min. are not encouraged.

In making up a bath for blackening, with Houghton's Houghto-Black, for example, the salt is mixed 50-50 with water and the temperature is raised to the boiling point of the solution (295 deg. F.). As rapidly as water is lost by evaporation at that temperature more water must be added.

A cold rinse should follow the blackening bath, then a hot rinse at about 170 deg. F. and then a dip into a heated 10% solution of a water soluble oil. The pieces are then drained and ready for assembly or shipment. Where parts are to be subjected to corrosive atmospheres for any length of time it is recommended that a light waxy, solvent type of rust preventive be applied for further protection instead of the dip in soluble oil.

Production time is often lost in the bath through the initial cooling effect of cold parts on the hot solution. Preheating of parts should be employed in such cases to prevent this fall of bath temperature when work is introduced. Similarly, the speed and effectiveness of the cold-rinsing spray is used to remove scum and prevent its adhering to the work. A typical cycle requires 5 stops of 8 min. each and requires the labor of only 1 man to keep baskets loaded and dump finished work.

The lustre of the black coating will, of course, depend on the original metal surface condition. To assure clean pieces, one maker of cartridge clips is dipping them into a 20% muriatic acid solution at room temperature to remove scale from the hardened and tempered blades. A cold water rinse then is followed by the regular blackening treatment already described, except that in this case the immersion time is extended to 15 min. The bath is large enough for several baskets, and each of the other stops in the cycle requires but 5 min.

The tank used for the blackening solution may be of welded boiler plate or mild steel—about the quickest-delivered material in today's market—with either immersion or external heating. Rinse tanks may be made of cast iron or galvanized material, although the latter should not be used for the pre-clean as an alkaline cleaner will attack the galvanized coating.

Not only as an emergency replacement for the more expensive, harder-to-get and slower-to-produce protective coatings, but as a normal-time surface treatment of steel, this blackening process is rapidly assuming an important place in metal processing.

[Other well-known and useful blackening processes or materials are available from Alrose Chemical Co., Providence, R. I.; Enthone Co., New Haven, Conn.; Heatbath Corp., Springfield, Mass., etc.—Editors.]

Electrolytic Pickling and Polishing

by Sam Tour

Vice President,
Lucius Pitkin, Inc.,
New York

Present demands for increased production requires the adoption of improved and new techniques in metal finishing.

Considerable attention is being given to the descaling of the various metals and alloys. The stainless steels and stainless alloys such as Nichrome, Inconel, etc. are difficult to free from scale with ordinary techniques of still pickling. Stainless steels can be readily and efficiently descaled by means of the Blaut-Lang process (U. S. Patent No. 2,115,005) in which the scaled steel is treated as the anode in a bath of sulphuric and hydrofluoric acids.

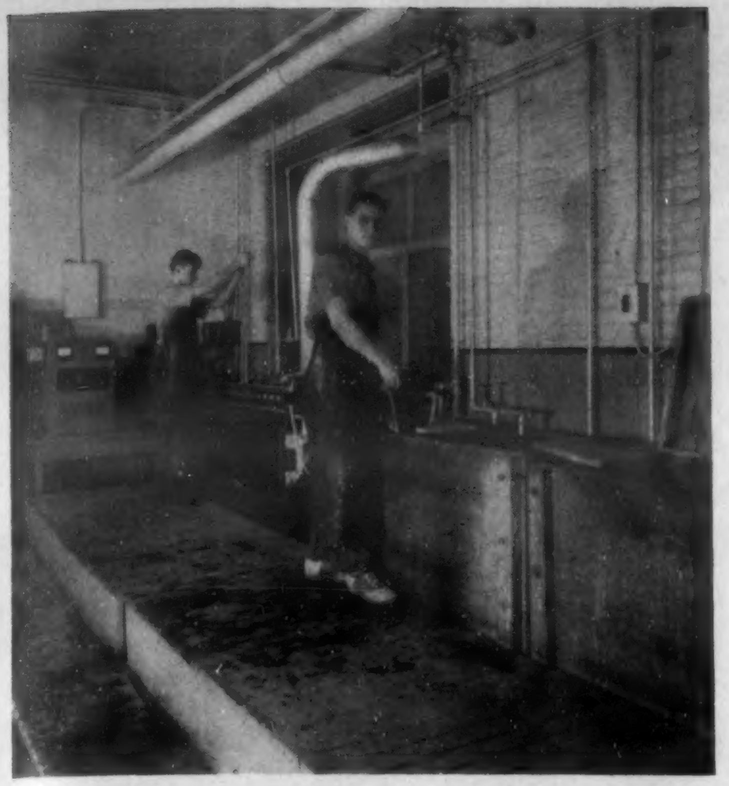
S. F. Urban (U. S. Patent No. 2,172,041) suggests the use of hydrofluoric, chromic and sulphuric acids as a still pickle for steels containing more than 12 per cent Cr.

Another recent process for electrolytic descaling of stainless steel is a cathodic treatment in a molten caustic bath followed by an immediate water dip, and then a sulphuric acid pickle followed by a nitric-hydrofluoric acid treatment. This method is said to shorten the time of scale removal as compared to the straight sulphuric acid pickle and to be of special advantage for straight chromium steels.

Nickel and its alloys, especially those of high chromium content can be descaled with great speed and cleanliness by anodic pickling in baths of phosphoric and sulphuric acids. By varying temperatures and current densities, these materials can be electropolished as well. An interesting application is the continuous descaling and electropolishing of strip and wire or individual pieces on a conveyor by passing through a two compartment tank in which the electrolyte in both compartments is identical but the physical conditions in one compartment favors descaling and in the other polishing. (Patents applied for.)

Electrolytic methods of polishing offer great opportunities to speed up production in the defense program. These methods of polishing have been successful with stainless steels, plain carbon steels, aluminum, nickel, monel metal, nickel silvers and various other alloys as well. Most of the methods which are used employ mixtures of sulphuric and phosphoric acids, citric and sulphuric acids, or straight phosphoric acid. In all cases, the material is treated as the anode with relatively high current density.

In the case of aluminum, it has been found very simple to electropolish and anodize in the same continuous line. Both the polishing and anodizing are



Typical installation for electropolishing of stainless steel.

done in the same tank consisting of two compartments, each compartment holding the same electrolyte but maintaining physical conditions favorable for electropolishing in one and favorable for anodizing in the other. The anodic layer formed is transparent and capable of absorbing dyes. Ordinary 6 to 12 volt generators are used throughout.

A most advantageous and time-saving application of electrolytic polishing is found in the treatment of ordinary carbon steel. Without reracking parts are descaled, electropolished, plated with copper and then with nickel or a very adherent nickel plate is applied directly to the iron. Other base metals may be similarly treated. Good economics result from such continuous operation.

Electropolishing has also found application as a ready means for reducing surface friction, rounding screw thread contours, and a multiplicity of other time-saving operations.

★ ★ ★

Shell forging equipment is available that will produce up to 200 per cent more than other conventional equipment and at the same time save steel and machining time. For example, in the Witter shell-rolling process, a 3-roll mill in conjunction with a machined mandrel produces a smooth uniform cavity in the shell forging. Hourly rates are 280-290 shell forgings per hr., depending on their size.

—Salem Engineering Co.

Thirty-six sheets of aluminum alloys up to 20 ft. by 6 ft. may be heated in one batch in the 1000-kw. quenching-type elevator furnaces recently put in operation. Features facilitating production are: Automatic quench control, high-speed hoist, recirculating-air heating with proportioning control, and roller conveyors for handling the loads.

—General Electric Co.

★ ★ ★

Maintaining constant temperature and humidity conditions is of considerable importance in speeding-up the production of certain vital defense products. Precision grinding spindles, which operate at speeds of 50,000 r.p.m. and which must be perfectly balanced, are assembled in an air conditioned room. Some delicate airplane instruments require a humidity of not more than 35 per cent; air conditioning is quite essential in the assembly rooms and inspection and testing departments for these instruments.

—Carrier Corp.

★ ★ ★

Electric resistance metal heaters are receiving wide application for hastening certain heating operations. Rivets 7/8 in. diam. and 2 5/8 in. long, can be heated and driven at the rate of 313 every 30 min., using an electric rivet heater. On bar stock, too, electric heaters can save much time. Seventeen-in. heats on 1 1/2 in. to 2 1/4 in. diam. stock can be made in 3-4 mins.; 1 1/2 in. square bars, 15 ft. long, can be heated to a rolling temperature in 1 1/2 min. with decarburization of less than 5/1000th of an inch.

—American Car & Foundry Co.

★ ★ ★

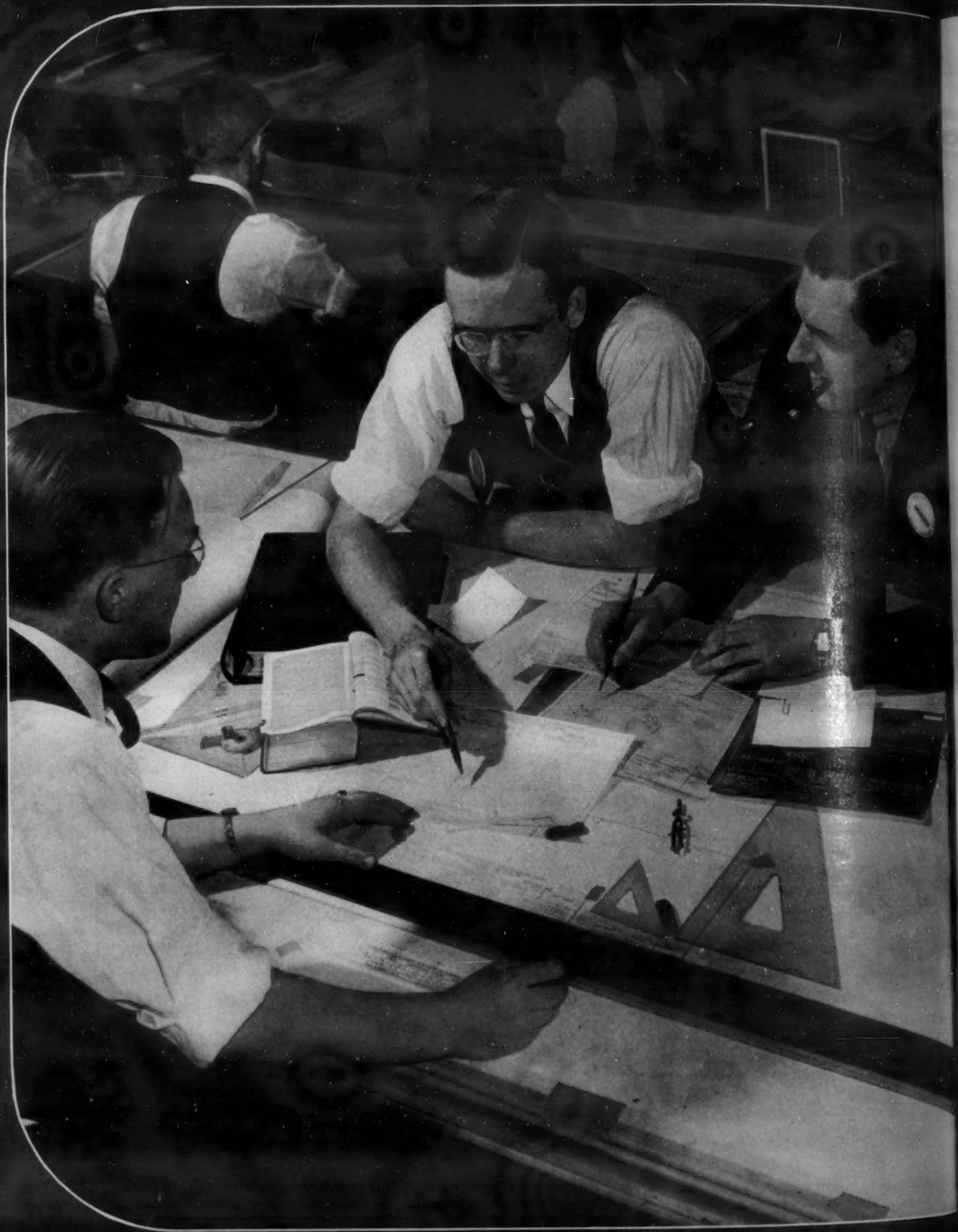
Big cylinder sleeves for liquid-cooled motors are now hardened in a 65-kw. immersed-electrode type electric salt bath furnace, eliminating distortion and rough grinding operations formerly necessary after the heat treatment. Immersed in molten neutral salt at 1550 deg. F., and quenched over a mandrel in oil, the sleeves hold diameters to 0.007 in. at production speeds of 120 cylinders every 7 hrs.

—Ajax Electric Co.

★ ★ ★

Graphitic steel dies being used in a gun shell forging shop are turning in a phenomenal service record. Several of these being used to cold nose 105-mm. shells have turned out 50,000 pieces each and still show no appreciable sign of wear. Previously, 4,000 impressions were regarded as maximum shell nosing die performance. The saving in set-up time, die-production time, and machine-tool capacity thus afforded is obvious.

—Timken Roller Bearing Co.



FASTER PRODUCTION

—DESIGN AND MATERIAL SELECTION

Carbon Steels and Defense Conditions

by H. W. Gillett

Heat-treating departments don't like to have to vary their temperatures or explore the different modifications in practice necessitated by unfamiliar steels, and steel mills don't like to make up special heats. When the necessity for substitution arises, both have to make a shift, and the tendency has been to shift to some other commonly made and stocked S. A. E. steel in place of the one previously used and containing scarce elements like nickel.

If too many people pick the same alternate composition, the trade leaps out of one bottleneck into another. Substitution of chromium-vanadium steels for nickel-containing steels thus brought about a tightness in vanadium and didn't do the chromium situation any good.

For a real surcease from scarcity of alloying element, it will be necessary to make a longer jump. It appears probable, according to Boegehold, that such steels as one with about 0.70 Si, 0.70 Mn, 0.50 Cr, 0.15 per cent Mo, with various carbons, will serve in place of almost the whole group of S. A. E. alloy steels for quenching and tempering, while one of 1.00 Mn, 1.00 Si and 0.12 to 0.30 per cent Mo will serve for case hardening purposes. While the manganese and chromium contents might have to be driven down a bit and molybdenum upped a bit, should manganese and chromium become too scarce, yet the move is in the right direction. To make this move, intelligent disregard of present usage and present specifications, has to be had. The compositions are intelligent ones, they utilize the ferrite-strengthening power of silicon to replace that of nickel and the carbide forming effects and the splitting up between, and the entry into both ferrite and carbide, of manganese and molybdenum are utilized to replace these effects that have previously been brought about by a heavy dose of chromium.

In low carbon structural as well as in the mild alloy steels, it should be feasible, since it is well proven in the latter case, to cut down on manganese and raise the phosphorus, which is a good ferrite strengthener. This replacement by phosphorus may not be entirely unusable even in some heat-treated parts, once we shake ourselves loose from old tradition and old specifications and consider merely the engineering properties needed in the part to be made.

Proceeding further along this line of thought, the real needs of the part in its final form, the use of any alloy steel for parts to be quenched and tempered in sections so small that they will harden through, should be scrutinized with care. And for carburized parts, the use of alloy steels in order to get a tough core—when tested *without* the case—is often quite unwarranted, since the piece seldom requires toughness anyway and the carburized *part,* as a part, isn't tough, despite the core, because a crack in the case will propagate through the core despite its alleged toughness. In heavily carburized parts the case is made thick, not because we expect to use all that thickness to provide material to be worn away in service, but merely to give support to the surface, the working face. If the hard surface is backed up by a strong, relatively hard core, a thin case, quickly produced by gas carburizing, cyaniding, etc., or almost instantaneously produced by flame or induction hardening, may do quite as well.

For suitable backing, the depth of hardening obtained in medium, forging grade, plain carbon steel is often quite adequate. It is clumsy to use low carbon alloy steels and spend a long time carburizing them when an easily obtainable carbon steel can be processed in a jiffy to give something usually quite as good.

Let's not forget the carbon steels! Let's reserve the scarce alloying elements for those steels in which each alloying element plays an unique and non-substitutable role!

Role of Plastics

by J. Delmonte

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Los Angeles, Cal.

It is not surprising to observe that in the new industrial activity inspired by national defense requirements, plastics are playing prominent roles. Well adapted to mass production methods, molded plastics are bringing their qualities of low manufacturing costs, lightness in weight, resistance to

Fig. 1. An internal gear molded of phenolic plastics.

chemicals, heat and electrical insulating properties, and desirable mechanical characteristics to many industrial parts.

While shortages of certain metals have contributed in part to increased activity in the field of plastics, the plastics industry abhors the use of the term "substitutes," because it feels that there are many applications which ultimately would have reverted to plastics. Notwithstanding, a large measure of the present consumption in plastics is occasioned by two basic motives: (1) their use will permit the release of strategic metals for defense purposes, where only the metal will suffice, or (2) rate, volume, or quality of production may be singularly fulfilled by plastics.

While the physical and chemical properties of plastics are of such character as to prohibit promiscuous use in every application which arises, reasonable care in analysis of design and study of operating conditions will soon reveal the proper type of material to employ. For example, highly popular in the new industrial activity are impact-resistant phenolics as well as ureas, polyvinyls, polyacrylics, polystyrene and cellulose derivatives.

To illustrate a few typical examples, the internal gear shown in Fig. 1 is molded of phenolic plastics. Production men acquainted with machining time required for internal gears will appreciate the advantages of molding such units in mass production. Multiple cavity molds can turn out several plastic gears every few minutes, whereas time for machining individual units is excessive. The accuracy with which the gear profile is produced depends largely upon the accuracy with which the mold was ground and polished to size. Of course, the horsepower rating of plastic gears would not be equivalent to steel gears of corresponding size, but the designer can specify a slightly larger gear for greater factor of safety. In passing, it is well to note that water is fully as good as oil as a lubricant for phenolic gears and bearings.

Fig. 2. A washing machine agitator made of plastic material.

Another striking example of the use of plastics to release aluminum for aircraft construction is depicted in Fig. 2, a washing machine agitator. Lightness, strength, and resistance to washing solutions are properties of aluminum, as well as of plastics. In fact, increased rates of production are understandable when one of the sand-cast aluminum agitators is compared with a molded plastic. Not only are unlimited units obtained from the plastic mold, but also the pieces are removed from the mold with a high polish, practically eliminating costly and time-consuming finishing operations required of sand castings. The same high surface luster contributes to washing efficiency, because of the ease with which clothing slides off of agitator arms and surfaces during washing.

From this brief discussion it should be apparent that plastics have characteristics which merit attention when speed-up of production is required. Certainly they are not panacea for all design problems, but when applied in proper manner they are of unquestionable value.

Finishes for Metal Products

by H. S. Rawdon

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As the name indicates, the "finishing" of a metal product is essentially the concluding operation in the process of fabricating the product. Commercial finishes differ widely in nature and they range from simple mechanical surface treatments, such as sand- or shot-blasting, polishing, buffing, and the like, to the application of highly decorative and protective surface coatings. The metallurgist's interest in "finishing" usually relates to the means used to render the metal surface resistant to the deteriorating agencies of corrosion and erosion, although the decorative aspects can never be entirely ignored even under stringent conditions such as those of the present. It is the protective aspects of the finishing of steel products which will be considered in this brief discussion of the finishing of metals as modified by the present conditions.

The defense-program restrictions on the ordinary civilian uses of zinc, tin, and nickel, the most widely used metals for coatings, have forced consideration of other metals for this use as well as of more economical coating methods.

Of all the metals now available in quantities great enough to warrant consideration of their unrestricted use as coatings of steel products on a wide scale, lead is outstanding. The use of lead for this purpose is receiving wide commercial consideration despite the

fact that a small alloying addition, usually of tin or other strategic metal, is necessary in order to ensure proper bonding of the coating to the steel base. Already lead has been adopted by some large manufacturers as a replacement of zinc for various steel products ranging from woven-wire stucco reinforcement to miscellaneous pole-line hardware. The metal possesses many properties which distinctly favor its use as a coating for steel. The multitudinous rust specks that "pepper" the lead surface soon after exposure to the atmosphere are more usually undesirable from the standpoint of an unattractive surface appearance than because of deterioration by deep seated corrosion of the steel beneath. As a base for painting, lead coatings are unexcelled, as evidenced by the excellent performance of terne plate as a roofing material.

Economy in the use of zinc as a coating, granted that it is available for this use, is a factor of increasing importance. Electroplating is outstanding in the metal-coating industry as a means for making a small amount of metal "go a long way" and the increasing use of this method for the zinc coating of semi-finished steel products, sheet, strip, and wire, is very encouraging. However, the hot-dip coating industry has not acknowledged a "knock-out" in this field but has accepted the challenge and recent developments plainly indicate the feasibility of producing coatings by hot dipping which can compete with those of the other type.

However, it is by no means necessary nor desirable always to use a metal coating as a finish for the protection of steel. Conversion of the surface metal into a compound by suitable chemical treatment so as to increase the resistance of the surface layer is a method employed in a number of ways. Outstanding among these is the phosphatizing treatment. Although the surface film of ferrous phosphate, in itself, is limited as to the degree of protection it can give to steel, in combination with a paint, or lacquer coating, it is widely used with eminently satisfactory results.

A method of this general nature, recently proposed as a possible replacement of the tin-lead coating on the inner surface of soda-acid portable fire extinguishers, consists in the phosphate treatment followed by impregnation by means of a dilute solution of asphalt varnish in a volatile solvent. Such a coating shows much promise for use on other containers, such as garbage pails. In addition to furnishing a hard protective surface layer, it serves in the same manner a galvanized layer does, i.e., to seal all crevices and make the container watertight.

Among other finishes which should find increasing application are lacquers, particularly those of the air-drying type. The use of pretreated stock out of which the product can be formed has already proved commercially feasible. A more extended use of this method is greatly to be desired.

Powder Metallurgy

by Fred P. Peters

Associate Editor

The "faster-production" demands of *this* emergency are drawing on a fabricating process that was not widely employed for the manufacture of formed parts in the last war. This production method—the molding of parts to finished dimensions by pressing powdered metals in dies and then sintering—has only recently risen to prominence as *another* (and often faster or better) way of making certain parts ordinarily fabricated by casting and machining, by die forging, by stamping, by die casting, etc.

It is obvious that molding to finished dimensions (pressing, sintering and repressing *can* keep within dimensional tolerances of $\pm$ 0.001 in. radially and $\pm$ 0.005 in. axially) saves subsequent machining time and thus also releases valuable machine tools for other work. Also, powder metallurgy presses are available that can produce small parts at rates up to 500 per min., although production rates are normally between 25 and 150 per min.

Production Factors

But the fact that this is being done with certain parts should not lead to the conclusion that powder metallurgy fabrication is the final answer to the faster production of small parts in general. The design of the part must be such as to accommodate this somewhat inflexible process, its operating conditions must be satisfied by the relatively low mechanical properties of many powder-compacts, and material-cost factors must be considered.

For example (as Patch has pointed out), powder metallurgy fabrication of iron parts, from the high-production standpoint, is economically more advantageous than casting-and-machining when the ratio of machining cost to raw-material cost for the conventional design is so high that any reasonable practice that eliminates machining will effect a substantial reduction in total cost.

Similarly, the number of parts to be produced in the same design must be large, since dies and tools are expensive. Conversely, powder metallurgy therefore is peculiarly advantageous for maximum production volumes. In one plant 10,000,000 flanged bushings a year are being produced by powder metallurgy at costs that compare with those for similar pieces made from flat strip stock.

Design Considerations

No matter how great the production volume in which a part is to be made, however, the high-production-rate or low-cost advantages of the powder method will not be available if the design includes

re-entrant angles, undercuts or cross holes. True, the re-entrant angles or cross-holes may be subsequently machined out, or split dies may be used, but economy or speed of production are considerably reduced thereby.

Material factors, too, are extremely important in considering the use of powder metallurgy for faster production. Fellows, in discussing the iron powder situation, has emphasized that the hue and cry for a *cheap* iron powder to expand powder metallurgy's application should not blind engineers and designers to the more important factor, from the speed-of-production and actual-cost viewpoints, of having an *easily moldable* powder.

Engineering properties of the compacts, also, must be satisfactory. Seelig and Gordon have indicated that iron parts can be made by powder metallurgy at present with strength properties about the same as ordinary (25,000-lb.) cast iron or low-carbon steel. Brass and bronze parts, however, can be made by powder metallurgy with better physical properties than the cast materials.

Comparison with Other Methods

There are parts whose service requirements permit the use of either one of several different materials, so that the metallurgical design engineer may reasonably consider more than one fabricating process. In such cases he should remember that the *fastest* production is probably attainable by die casting, the least waste of material through powder metallurgy, the closest tolerances through screw-machining. Powder metallurgy's tool costs are likely to be among the highest; a process like cold-heading and forming *may* provide a better all 'round combination of low tool cost, high production rate, low material-cost and design flexibility.

Powder metallurgy is perhaps the fastest-growing of the high-production fabricating operations. As a means of saving machining time and making machine tools available for other uses, it merits the most careful consideration of every metallurgical design engineer entrusted with the responsibility of getting large-lot small parts made economically in the quickest-possible time.

★ ★ ★

The use of oil-retaining porous bronze bearings in machines is one way of expediting their construction as well as permitting ultimately higher operating speeds. Such bearings can be finished to accurate dimensions, provide an oily surface to start with, and assure an oil film to run on for thousands of operating hours. No oil holes, reaming and metal-waste are involved and simple, rapid assemblies are possible.

—Bound Brook Oil-Less Bearing Co.

Alloy Steels

by Earle C. Smith

Chief Metallurgist,
Republic Steel Corp.,
Cleveland

The industry of the United States must take a lesson from the English if our defense effort is to be of maximum effectiveness.

In this emergency the standardization of production which has been so widely practiced must be carried into new fields.

It took the battle of Dunkirk to make the English realize the vital necessity of standardizing steels. The result was the War Emergency British Standard Schedule of Wrought Steels for General Engineering Purposes.

The list of British steels is considerably under 100, including the stainless steels. Because our methods of manufacture are more varied, it is entirely possible that our list will have to be somewhat larger.

It is unfortunate that the American steel industry cannot profit by the work which the British have already done, but the results of their studies are still confidential and, therefore, cannot be made a rallying point for sensible specifications in this, The Land of the Free, while we still remain clear of the pressure of war dictation.

Though the bystander may not realize it, the pressure for production of defense materials is not yet very heavy as compared with what it will be a few months from now. Each specifying group, therefore, still looks forward to "business as usual" and feels it unnecessary to make any change itself. If changes are to be made they believe "let someone else make them." Changes are already here and a great many more are ahead of us. Brutally, either industry and the country in general will have to conform to necessary changes, or we will all find ourselves with a noose around our necks.

The most useful thing that could happen to the steel industry would be a definite and fixed plan under which our supply of alloys would be properly allocated among users in the order of their priority. This step should be taken while we still have a friendly nation acting as a barrier between us and possible enemies.

Such a plan should include all the steel required and be in the interest of getting out the maximum tonnage of usable defense steels.

For many years this country has had a surplus of steel producing capacity. We are now faced with a shortage of certain important types of steel. Definite steps have and are being taken to eliminate these shortages, but in some measure they still exist.

The deficiency in steel capacity is further aggravated by changes due to a lack of an ample supply

of some alloys. This shortage has come upon us with distressing suddenness and the industry will be in a state of flux for some time to come as methods are developed to render the shortages less serious. This will mean that we will make steel of such materials as we have at hand and in those types which can be delivered promptly.

At the moment, however, it appears as though we must be confronted with somewhat more urgent emergencies than exist today before we forget tradition and recognize "cold facts."

Industry should prepare for this change. We must simplify our group of steels in the interest of improved and speedier defense and production.

Gray Iron in Product Design

by Oliver Smalley

President, Meehanite Metal Corp., Pittsburgh

Today, in making decisions in the selection of materials and methods of fabrication, men of industry ask not only "How good is it?" but "How fast can we get it or build it?" Because we must produce more of everything with both diligence and speed, it has become necessary everywhere for manufacturers to squeeze the last drop from their sources of supply, from their own production facilities, and from every factor involved in their output.

In this connection the modern cast iron, both as a material and method of construction, has much to offer. Let us review the qualities which generally contribute to faster production, examining each of them in the light of what can be or is being done in today's circumstances.

(1) *Production time:* Modern foundry technique and organization have advanced a great deal by means of the application of modern production methods and machinery, with the result that iron castings in quantity can be manufactured comparatively rapidly from the time of delivery of the pattern to the plant. Foundry capacity in this country is great and usually casting deliveries may be scheduled regularly and can be depended upon.

(2) *Accuracy in casting to shape:* In many instances reliability of duplication of castings in volume is an important factor in fast production. Improved foundry practice today permits the regular day-by-day output of castings in volume which will conform regularly to size and dimension specifications as well as to the engineering properties demanded. Accurate coring for holes, in accordance with the casting design, can, for example, permit the elimination of boring and drilling operations, often demanding only a finish reaming. Machine tool, diesel engine, and munition manufacturers all find this of great assistance in maintaining production schedules.

(3) *Flexibility for design changes, permitting lighter sections:* Cast iron with its greater fluidity at ordinary pouring temperatures permits the casting of complicated shapes having wide variations of section accompanied by adequate strength without excess weight. This is important both to designers and fabricators who are faced with the constant cry of "Speed!" and yet must not sacrifice quality.

(4) *Machinability:* Of course, the easy machining properties of cast iron as opposed to steel are well known, and the chief problem in this connection has generally been the manufacturer's inability to secure castings uniform in properties and structure and at least relatively free from defects. Comparatively recent metallurgical developments, however, have solved this problem in many cases, reducing machining time losses and scrap returns.

Comparative machinability ratings for various cast and wrought metals have been established by the Dalcher rating system, which measures machinability by comparison of feed pressure in pounds—a method which is finding general acceptance since it provides a common rating standard. According to these figures (the most machinable materials have the smallest numbers) ordinary gray iron has a rating of 41; high-test iron (57,000 lbs. per sq. in. tensile), 67; Meehanite type GA (58,000 lbs. per sq. in. tensile), 48; Meehanite type GE (31,500 lbs. per sq. in. tensile), 38; annealed S.A.E. 1040 steel, 43; oil-hardened and tempered S.A.E. 3140 steel 53, etc.

The importance of savings in machining time is probably most greatly emphasized in the fabrication of units which recently may have experimented with welded steel construction or which, designed originally for construction with welded steel plates, are generally adaptable to the use of castings in fabrication. Successful use of castings in this particular field takes on added importance in view of the current supply situation in the steel industry.

(5) *Dependable engineering properties often without heat treatment:* Achievement of superior engineering properties of cast iron without the necessity of long and expensive heat treatment is a fairly recent and exceedingly important development. Castings are available today with "as cast" tensile strength in excess of 55,000 lbs. per sq. in. and with a true modulus of elasticity of 23,000,000 lbs. per sq. in. Foundry technique also includes a control of hardnesses and, in fact, all the important properties that may be required for a casting's specific service conditions.

A good case in point is the growing use and acceptance of cast crankshafts, which offer both production and basic design benefits. These crankshafts can, for instance, be cast to include integral balance weights in complicated shapes that could not be executed in steel forgings without leaving a sizable

quantity of excess material, which subsequently would have to be machined away.

As an example, one such crankshaft now being manufactured weighs 65 lbs. "as cast" and requires the removal of only 9 lbs. of metal by machining. The corresponding forging weighed 90 lbs. as forged and required the removal of 24 lbs. of metal by machining before completion period. The finished crankshaft still, however, would be 10 lbs. heavier as a forging than the cast shaft.

This particular example is also indicative of the better engineering properties that can be contributed to the unit since the pearlitic matrix of the iron, interspersed with free graphite flakes, provides the crankshaft with a lower coefficient of friction at the journal and superior rigidity. In addition, the higher damping capacity of cast iron permits the shaft to nullify vibratory stresses set up in service and contributes a reduced sensitivity to notching, which so often weakens steel.

Outstanding examples of speed in production are provided in munition manufacture where the wear-resisting and self-lubricating properties of cast iron shell-nosing dies, shell draw rings, and a wide variety of stamping dies are utilized. Specifically, such shell-nosing dies replacing alloy tool steel and used on the hot-nosing of shells have given a record yield of over 3,700 shells for the die's period of useful life. Previous dies had been able to produce only 333 shells. Similar dies are being used for the forging of 40-lb. bombs from steel billets 3 in. in diam., the final bomb having a wall thickness of ¾ in. Production has run as high as 3,500 bombs without re-finishing of the die.

Steel Castings

by C. W. Briggs

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Cleveland*

With the steel casting industry at 100 per cent production at the present time it is believed that a few suggestions to buyers of steel castings would be timely in assisting steel casting manufacturers in speeding up deliveries and in this way increasing the total tonnage output in any time period. The following suggestions are offered to buyers of steel castings.

1. *Specifications:* If it is necessary that castings be bought on specification, use one of the American Society for Testing Materials specifications for steel castings. There are 13 specifications with 50 classes available. Foundrymen are familiar with these specifications and know what is wanted. Private specifications have often not received the study that has been given the A.S.T.M. specifications and hence, rejection limits are not compatable with normal expected values as attained by commercial manufacture. Such conditions result in the slowing down of production and increasing production costs unnecessarily.

2. *Design:* The characteristics of steel casting design are extremely important as to the speed with which the production of a casting is carried on. It is suggested that on all new designs the buyer consult the foundry operating executive before the casting design leaves the drawing board. Foundrymen are able to give helpful pointers on design so that the work better fits their molding equipment. They also can give the buyer suggestions on the joining of sections, the location of cores and many other items that will result in direct saving of time and cost of production of the casting.

There are a number of fundamental rules in the designing of steel castings, which if adhered to, will materially increase production as defective castings are less liable to be encountered. These rules are as follows:

A. An attempt should be made to design all sections in a casting with uniform thickness.

B. It is not desirable to design cast steel structures with abrupt changes in sections.

C. Sharp corners at adjoining sections are sources of defects, and if possible, should be eliminated.

D. When the design of a one-piece cast steel structure would be very complicated or intricate, it is suggested that it be broken up into parts so that they may be cast separately and then assembled by welding.

E. In designing unfed joining sections in "L" or "V" shapes, it is suggested that all sharp corners at the junctions become slightly smaller than those of the arms.

F. In designing sections that join in an X section, it is suggested that two of the arms be offset considerably.

G. In designing any joining sections, it is suggested that all sharp corners at the junctions be replaced by radii. In the case of unfed "T" and "X" sections these radii should not be large.

3. *Patterns:* Casting purchasers who supply their own pattern equipment for the production of castings should study the foundry's pattern requirements carefully. They should consult with the foundry so that they may be able to select the pattern equipment that will give them the desired pattern life at the most economical figure that will allow for the greater speed of production. In this regard match plates and metal patterns are two types that allow for maximum speed with high degree of mold reproduction accuracy.

4. *Models:* Considerable time may be saved on pattern construction of intricate castings if models are built to scale. The model will assist the designer in making the prospective casting more castable. Patterns can be constructed faster and at less cost than it takes to make both pattern and model. The model can be used on the foundry floor as an aid in casting production. It can save considerable time in bringing about necessary changes of design and in checking mold tolerances. In the cleaning room

alone models will save considerable time, especially if it is necessary to remove padded sections placed because of solidification and feeding requirements.

5. *Tests:* It is suggested that unnecessary tests be eliminated. Casting shipment is held up, floor space is occupied that could be turned over to other castings if a great number of test specimens must be machined and tested before the casting is shipped. Important tests that are necessary, of course, should and must be made but miscellaneous tests should be kept to a minimum.

6. *Compositions:* Production can be increased by using steels consistent with the needs. Do not request an alloy steel if a carbon steel will do equally as well. It may be necessary to delay production on your job until enough work is collected to allow for the running of an entire heat of a certain alloy grade. Stick to carbon grades if properties will permit. If not, make use of the well known grades of alloy steel since there will be more of this type of steel going through the shop and production can, therefore, be speeded up.

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Indium treatment of parts affected by wear and corrosion reduces the necessity of replacement and thereby avoids delays in production. In one case, connecting rod bearings lined with cadmium-silver-copper alloy were treated on the surface with about 0.20 per cent In. They stood up almost three times as well as the un-treated bearings.

—Indium Corp. of America

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Machinability of Cast Iron

by C. H. Lorig

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Gray iron castings play an important role in both the first and second lines of defense. The all-important machine tools are literally based on gray iron castings and the mechanized units of the armed forces incorporate hundreds of different castings in their construction. The production problem centers, of course, in the foundries but it does not rest until the completely machined castings are ready to be put into service, be this machine tool or combat car.

Machinability is the final and governing consideration in speeding up the production of finished castings. If an increase in the total number of castings produced by the foundries is gained at the expense of machinability, the over-all production may be lowered and vitally important machine tool capacity may be wasted.

The purpose of this discussion is to point out some of the factors which affect the machinability of gray iron castings. Some of these factors are within the control of the foundries but some of them are within the control of the designers and the engineers who specify the materials used in construction.

In the first place, machinability can only be defined in terms of practice. It depends on many separate factors which include such things as:

1. The composition of the iron.
2. The structure of the iron.
3. The physical properties of the iron.
4. The surface of the casting.
5. The type of machining operation.
6. The service requirements of the finished casting.
7. The type of cutting tool used.

Since the influence of these factors is mutually related, a reference to machinability of gray cast iron must take into account the effects of all of them.

Both the composition and structure of cast iron have a pronounced effect on the machinability. From the point of view of composition, high carbon and high silicon contents tend to improve machinability at the expense of mechanical properties. From the point of view of structure a totally ferritic matrix makes for easy machining. As the matrix becomes more pearlitic, i.e. contains more combined carbon, and as the amount of graphite becomes smaller, cast iron becomes more difficult to machine. Its machining qualities are further impaired by hard spots and chilled edges, hence anything that decreases the susceptibility for the iron to chill tends to benefit its machinability.

Improved machinability with some sacrifice to strength and hardness may be obtained by an anneal at temperatures from 1400 to 1500 deg. F. This heat treatment increases the graphite and reduces the combined carbon content of cast irons.

While attempts have been made to express machinability in terms of the physical properties, a precise relationship between machinability and physical properties, applicable to cast irons in general, does not exist. The lack of some simple index of machinability among the physical properties is unfortunate, but is traceable to known differences that may be found in the behavior and structural make-up of irons which otherwise have approximately the same hardness or strength. Only when a given class of iron is to be machined under a definite set of conditions will Brinell hardness, or some other property, furnish a convenient guide to indicate machinability.

The final test on machinability of cast iron is in the machine shop. To maintain a high level of production or to accelerate production of finished castings where machinability is involved, the cooperative effort of the designer, the engineer, the foundryman, and the machine shop operator is essential.

Welding Design

by A. F. Davis

Vice President,
The Lincoln Electric Co.,
Cleveland

The design premise, that with welding you take standard rolled steel shapes and plates, calculate the type and dimensions needed, cut the members into the sizes wanted and fuse the parts directly together into a single unit, has led to remarkable progress in production of all types of industrial products and structures, and has been, and is, of vital importance in Production for National Defense.

Applied by the engineer and designer, welding imparts greater structural strength, speeds production and cuts weight and cost. It increases strength over cast iron construction because rolled steel is four times as strong and two and a half times as stiff as ordinary gray iron, and over riveted construction because the welded joint develops the full strength of the metal whereas, the joint riveted has to be weakened by drilling of holes.

Welding speeds production because it eliminates many operations required with other methods, such as the drawing and making of patterns and the excessive machining in cast construction, and the detailing, punching and excessive handling of extra connecting members in riveted construction.

Welding reduces weight over cast iron construction by virtue of the greater strength and rigidity of steel, requiring less metal for equal strength; over riveted steel construction by elimination of intermediate connecting members.

Reduced cost, with welding, is the logical result of the elimination of extra operations and saving of metal.

Innumerable examples could be cited to show the vital importance of welding to industry and, particularly, to National Defense. Typical examples include:

Savings of a half million tons of steel in construction of 705 cargo ships (report of U. S. Maritime Commission);

Saving of 20 to 25 per cent in construction time, 20 per cent on weight and 31.7 per cent on cost of beaching gear for large aircraft;

Saving of 15 to 25 per cent in construction time, 25 per cent in weight and 32 per cent in cost on field service truck body;

Saving of 19 hrs. and 35 per cent in cost of machining on metal cutting machine;

Saving of 38 hrs. and 15.5 per cent in cost of machining on die cutting press;

Saving of 31 per cent in time, 17 per cent in weight and 32 per cent in cost on 112 jigs and fixtures for production of mobile field equipment;

Saving of 10 to 12 weeks (required to obtain replacement) and 90 per cent in cost of broken metal stamping press.

One example of the vital importance of welding in National Defense production is the airplane landing gear fork. Arc welding cut 8 hrs. off production time, saved $40 per airplane on the two forks (per plane) alone and increased strength from 79,300 to 98,160 lbs. per. sq. in. This strength increase was 23.6 per cent. [See "Forging Versus Welded Assemblies," METALS AND ALLOYS, June, 1941, page 734—Editor.]

The expedient of simply replacing less modern methods with welding permits important advantages but designers, seeking maximum benefits from the process look to the following factors:

(1). Use of the type of joint which fully meets design requirements and costs least in preparation and welding;
(2). Utilization of forming and cutting to simplify assembly and welding;
(3). Proper fit-up of parts to reduce amount and cost of welding;
(4). Proper attention to sub-assemblies which affect the over-all production picture;
(5). Efficient use of jigs and fixtures;
(6). Use of the largest electrode that the job will stand;
(7). Use of modern high capacity arc welding sets.

Designers, determined to get all the benefits from welding have contributed, are contributing and can still contribute tremendous benefits to their companies, to industry and to society in general.

Cold-Drawn Steels

by F. J. Robbins

Metallurgical Engineer,
Bliss & Laughlin, Inc.,
Harvey, Ill.

Cold-drawn bar steels have become increasingly important in the last several years to all industry faced with the necessity of producing thousands of exactly duplicate parts as economically as possible. The present emergency, which is calling into use every available piece of machine tool equipment to make possible maximum production of our national resources, is likewise requiring greatly increased production of highly machinable cold-drawn bars.

Even though many efforts have been made to produce bars by hot rolling alone that would possess many of the characteristics of cold-drawn bars and, therefore, would machine with the same ultimate economic success, industry has found these efforts to be largely unsuccessful principally because of fabrication troubles and economic disadvantages. The use, therefore, of cold-drawn bars has constantly increased and now the production of defense requirements is calling for very large tonnages.

Four Primary Reasons

Essentially, there are 4 primary reasons for the widespread use of cold-drawn bars: (1) Close size

tolerance; (2) good finish; (3) high strength; and (4) excellent machining. All of these are dependent upon the fact that the steel bars are drawn through a die made to very accurate size of good tool steel or of tungsten carbide.

The bars are first rolled to a pre-determined size dictated by experience. Rolling scale is removed by pickling in a suitable acid solution—usually sulphuric acid of 3 to 5 per cent concentration at 150-180 deg. F.—after which the bars are washed and immersed in a hot lime bath which removes any remaining acid and leaves a lime coat on the bar surface which aids in the drawing operation to supplement the lubricant especially prepared for cold drawing. In drawing no metal is actually removed. The diameter of the bars is reduced a calculated amount by compression, and the bars are, therefore, elongated.

One effect of drawing bars prepared in this manner through a die is size accuracy. For example, for carbon steels up to 0.30 per cent C the diameter of which is 1 in. and under, commercial tolerance is plus 0.000 in. minus 0.002 in. As carbon content and bar size increase the tolerance naturally increases slightly, but at its greatest is only a very small fraction of the commercial tolerance to which bars can be hot rolled.

The result of such accuracy is immediately apparent to those interested in the fabrication of parts on machine tools. Collet life is much longer, because their action is more uniform and positive. Cutting edges of tools are preserved over a far longer period because a uniform amount of metal is removed by each one, and the first-operation tools are not required to compensate for large irregularities in bar size. Thus, machine upkeep and tool cost are maintained at a minimum.

Removal of rolling scale by pickling, the compression in passing through the die and careful supervision of the application of lubricant and the actual drawing process result in a scale-free, smooth bar surface. After drawing, the bars are mechanically polished on specially designed equipment. The result is a smooth, shiny finish which does very often suffice for the finish requirements of the part being fabricated. In using cold-drawn bars, therefore, it is necessary to remove only the minimum required for shaping the part and the cold-drawn bar surface is used to the greatest possible extent. This surface can also be used for some types of bearings run directly on it and for part surfaces to be subsequently coated in some manner, except, of course, where very fine polished surfaces are required. The economic advantage of this is readily apparent.

The action of the die in reducing the bar diameter results in cold working the steel. The amount of the cold working depends upon the analysis of the steel, and the amount of the reduction. The effect, however, is to increase the hardness and the tensile strength. The yield strength is increased in much greater amounts than hardness or tensile strength while the elongation and reduction of area are proportionately reduced.

In Bessemer steels, for instance, the yield strength is often doubled while the tensile strength is increased as much as 30 per cent. Open hearth steels, which do not cold work to the same extent, show a marked increase in these properties.

Sub-Critical Temperature Anneal

Frequently, a sub-critical temperature anneal is employed further to increase hardness, tensile and yield strengths above the values as cold drawn. Further, such a strain tempering results in restoration of the proportional limit to a high value as well as an increase in ductility.

In steels of medium carbon content when heavily cold-worked and subsequently tempered this factor is very important because no warpage or distortion are minimized and it is not necessary to heat treat parts made from steels produced in this way.

For example, in sizes up to 2 in. round, hardnesses up to about 300 Brinell and yield strengths above approximately 100,000 lbs. per sq. in. can be obtained. At the same time elongation and reduction of area are maintained at a high level. An article in *The Iron Age* for Dec. 14 and 21, 1939, entitled "Strain Annealing," discussed this subject in detail.

The cold working performed upon all cold-drawn steels makes them stronger and harder than bars that have not been cold worked. The physical properties of such steel bars are suitable for thousands of parts that are used without any subsequent heat treatment. Improved part finish is a factor in such uses too since wear resistance is to a great extent dependent upon a smooth surface free from torn and ragged tool marks.

When part requirements are such as to demand high hardness and high mechanical properties, the parts are heat-treated after fabrication. Cold-drawn bars are, of course, used for such parts too because of economy, high production, part finish, tool life, etc.

Increase In Machinability and Tool Life

To all industry, probably the most important effect of cold drawing, is the increase in machinability and tool life and the improved part finish resulting from its use. Primarily this, too, results from cold working. Increase in tensile, yield and hardness and the decrease in ductility (i.e. elongation and reduction of area) eliminate gumminess or mushiness in the softer areas. This allows the tool to pass through those areas more readily and avoids the development of high frictional heat. This means higher cutting speeds and longer tool life, resulting in more parts per hour, as well as greater machine efficiency, measured by machine downtime per hr.

Elimination of a soft, mushy condition, improves the part finish markedly by avoiding any tendency to tear and pull during the cutting action of the tool. Thus, the amount of stock that has to be left for finishing is decreased and the cost of secondary operations reduced, or even in some cases eliminated entirely.

★ ★ ★

A prominent manufacturer of heavy electrical equipment has found the process of metal-spraying of great value in saving time and money. Certain parts needing silver contact surfaces were formerly electro-plated, requiring 15 hrs. to obtain a sufficiently heavy silver deposit. With a metallizing gun, the same results are now obtained in 5 min.

—Metallizing Co. of America

★ ★ ★

Silver Brazing Alloys

by Robert H. Leach

Vice President,
Handy & Harman,
Bridgeport, Conn.

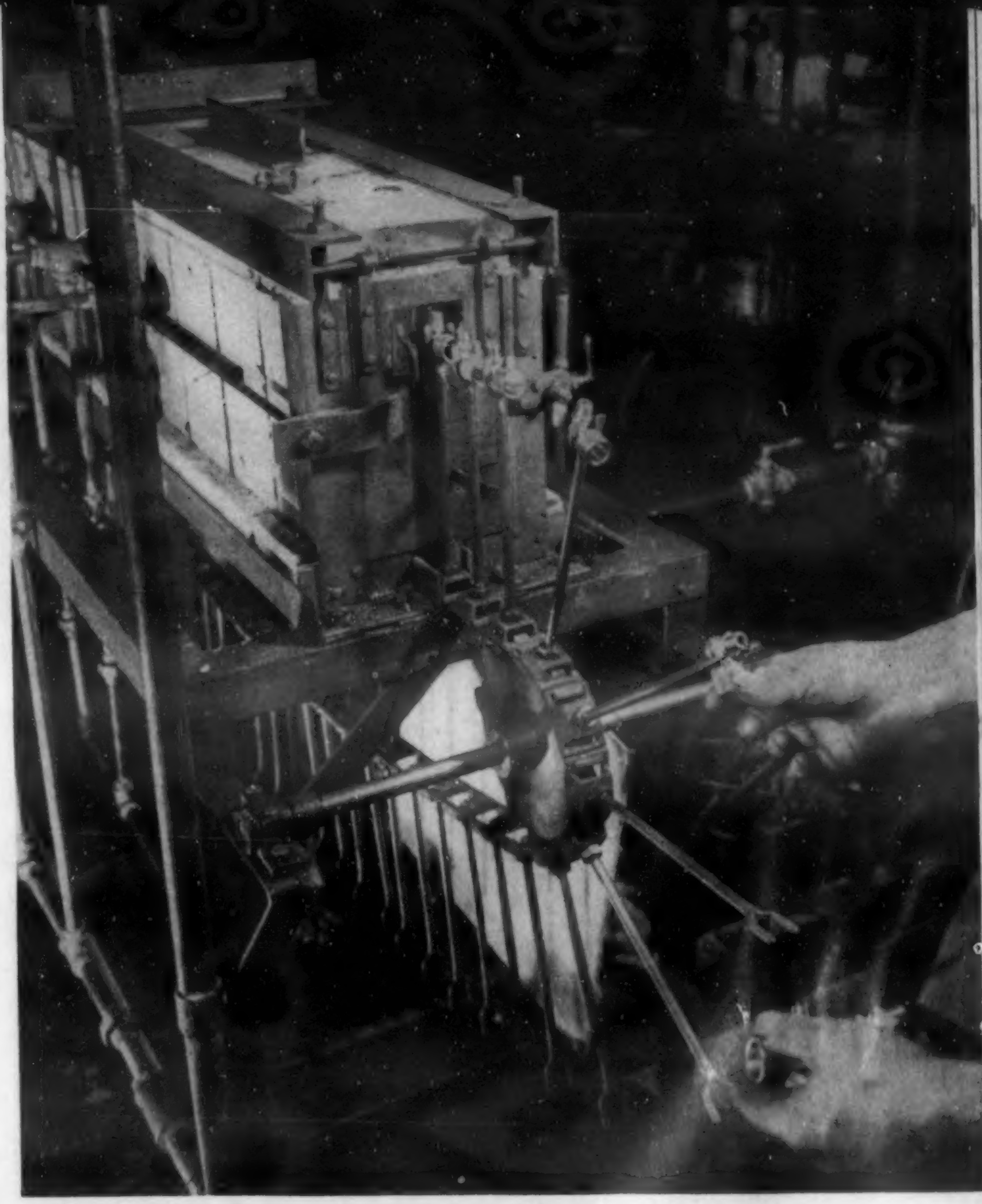


Fig. 1. Brazing brass primer cups with "Easy-Flo."

Fig. 2. Brazing rotor bars to end rings with "Sil-Fos."

The rapid increase in the use of silver brazing alloys for the manufacture of a wide range of products has been an outstanding development during the past few years. Commonly called silver solders for many years, these alloys have had a limited use for centuries but the modern methods of producing many kinds of equipment have created a large number of industrial uses for silver brazing alloys.

The melting point of standard silver brazing alloys runs from 1325 to 1600 deg. F. depending upon the composition. Two proprietary alloys, "Easy-Flo" melting at 1175 deg. F. and "Sil-Fos" melting at 1300 deg. F. have the advantage of still lower melting points and at the same time produce strong, shock-proof and corrosion resistant joints. Their free flowing properties at temperatures several hundred degrees below those required for the use of copper welding rods and base metal brazing alloys make it possible to flow these alloys into closely fitted joints quickly with minimum chance of damage to the members that are being joined. "Easy-Flo" and other silver brazing alloys can be used for making joints on either ferrous or non-ferrous metals and also on dissimilar metals.

The use of closely fitted joints gives greater strength and results in economy because such a small amount of the alloy is necessary. Further economies in the use of these alloys are as follows: Saving in time and cost of labor, lower heating costs and lower finishing costs because of neatness of joint. Repeated instances have occurred on production jobs where

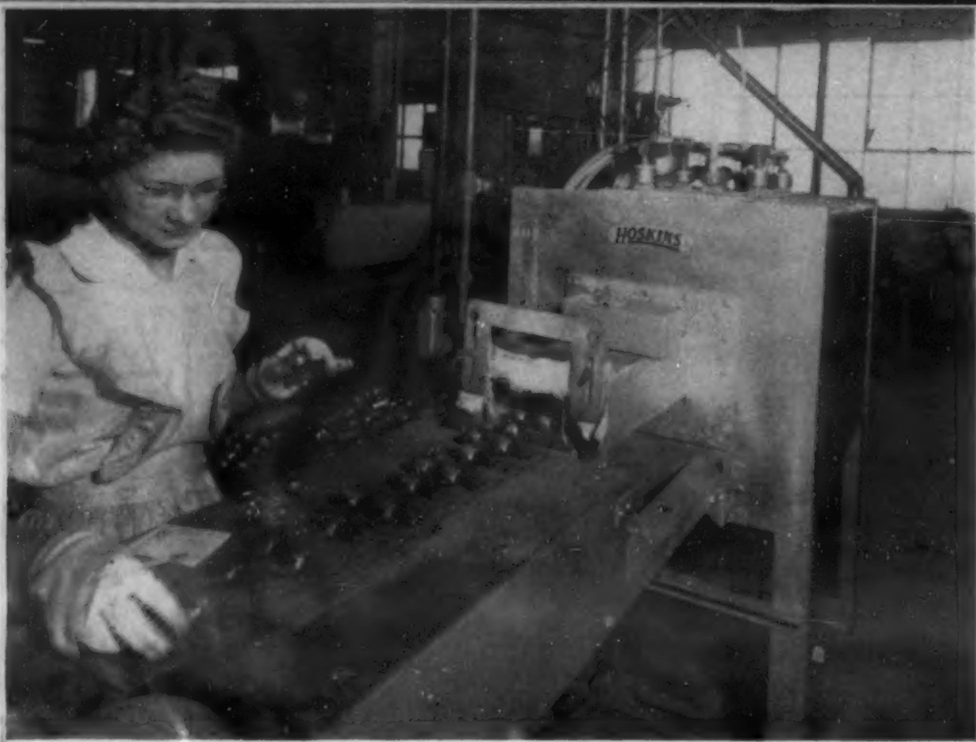


Fig. 3. Brazing a Monel metal dehydrator with "Easy-Flo."

Fig. 4. "Sil-Fos" brazed copper heater, 3/16 in. thick 10-in. seam, 6-in. inlet and outlet connections.

even the actual cost of the silver brazing alloy per joint was less than that of the base metal alloy which it replaced because a much smaller amount was required.

These alloys are malleable and ductile and can be supplied in the most convenient form of sheet, strip or wire. Inserts in the form of rings, thin sheet or strip can be preplaced in assemblies before heating thus assuring that the proper amount of the alloy will be present and at the same time waste will be eliminated.

They are adapted to practically any method of heating: Torches using all kinds of gases with either air or oxygen, different types of furnaces, electrical methods of heating including induction, resistance, incandescent carbon and carbon arc; dip brazing either using a molten bath of the brazing alloy or by immersing the assembled unit with the alloy preplaced in the joint, in a bath of molten salt.

Fig. 1 illustrates how the production of brass primer cups was increased from 60 to 800 units per hr. by the use of "Easy-Flo" rings as inserts between the two parts of the cup. The assembled units are placed on the holder bars and passed through a torch heated furnace. At the exit end of the furnace the brazed cups are cooled until the alloy sets and then dropped into a tank of water.

Another manufacturer reported that the use of "Sil-Fos" silver brazing alloy for brazing rotor bars to end rings as illustrated in Fig. 2 reduced the brazing time from 6 hrs. to 1½ hrs. with improved quality of work.

Fig. 3 illustrates a production set-up for brazing a Monel metal dehydrator. In this case a head and a bracket must be brazed to each dehydrator body. On each dehydrator a ring of 1/16-in. "Easy-Flo" wire is placed between the body and the head. This assembly is then placed on the moving belt with the bracket in place and a short piece of "Easy-Flo" between the bracket and the body. The belt carries the complete assemblies through an electrically heated furnace at a speed that produces 400 completely brazed dehydrators per hour. The low flow point, 1175 deg. F. of "Easy-Flo" not only makes this speed possible, but insures that there will be no damage to the Monel metal parts.

The use of these alloys is not limited to small parts. The large heater illustration Fig. 4 is made of 3/16-in. copper. The 7 ft. 10-in. seam and 6-in. inlet and outlet connections were made with "Sil-Fos" in 1½ hrs., and according to the manufacturer the job would have taken a full day with spelter.

Large quantities of these alloys are going into many different kinds of defense work, and the Navy and private yards are using them on piping and fittings from ⅛-in. dia. to flanges 40-in. in diameter. By their use it has been possible to speed up production and overcome fabrication difficulties because of their low melting points and strong leak proof joints. They have been particularly effective for joining dissimilar metals.

Any manufacturer who is confronted with joining problems should investigate the use of these silver brazing alloys as a solution of his difficulties. Although it cannot be claimed that they have the magic power of the silver bullet in the story of Emperor Jones, it is true that their use is playing a rapidly increasing and important part in our Defense and Armament Program.

★ ★ ★

Critical metals—nickel and chromium—may be conserved and production expedited by using special alloyed irons which have good resistance to temperatures and furnace atmospheres below 1400 deg. F. Design must be related to the service condition, just as it should be with the high nickel-chromium alloys.
—Sterling Alloys, Inc.

Bronze-Welding in Repair

by W. S. Walker

Manager of Process Service, Eastern Div., The Linde Air Products Co.

Keeping down repair costs, maintaining equipment in condition for high operating efficiency, and having machines ready for service when required are major problems in all industrial plants. The problem is particularly important now in defense industries where machines are needed for practically uninterrupted operation. The maintenance shop consequently holds a key position in efficient plant management, since the slowdown in production time resulting from machinery breakdowns can represent a serious loss unless the repair method is speedy as well as dependable.

In oxy-acetylene bronze-welding, plant maintenance men have at hand a repair method that is speedy, dependable, and economical, and one that is also readily available to all parts of the plant, since the equipment used is portable.

No other welding method can quite equal the general all-round usefulness of bronze-welding because of the readiness with which bronze weld metal will form a bond of excellent strength with a large number of metals that have a higher melting point. These include cast iron, malleable iron, carbon steels, alloy steels, wrought iron, galvanized iron or steel, sheet metal, copper, brass and bronze, nickel and Monel. Although the base metal is not actually melted in bronze-welding, the unique characteristics of the bond between the bronze weld metal and the base metal give a joint that is comparable to a fusion weld. This wide applicability of bronze-welding is of obvious importance in plant maintenance where practically all commercial metals are encountered.

Hardly a day passes in the average plant, regardless of size or industry, where bronze-welding cannot be of considerable service for repair and maintenance. These applications can be classified under two general headings—repair of fractured sections and the bronze-surfacing of worn parts.

Bronze-Welding in Repair

Foremost among repair tasks that bronze-welding is called upon to perform is the salvage of castings that through hard service or by reason of accidents have been cracked or broken. Castings that form a vital part of plant equipment, such as furnace sections, machine bases, pump and boiler sections, bearings, cylinders, housings, valve bodies, gears, and machinery parts can often be restored in no other manner.

Bronze-welding is particularly well adapted for welding cast iron. As it does not require melting of the base metal, the considerations necessary to insure the proper gray iron structure in a fusion weld are completely eliminated. Because of the lower temperature required, preheating is greatly simplified, preheating of the entire casting seldom being required. The use of only local preheating at a relatively lower temperature often makes it possible to effect repairs to broken machines in place, thus saving the time and expense of dismantling and reassembly.

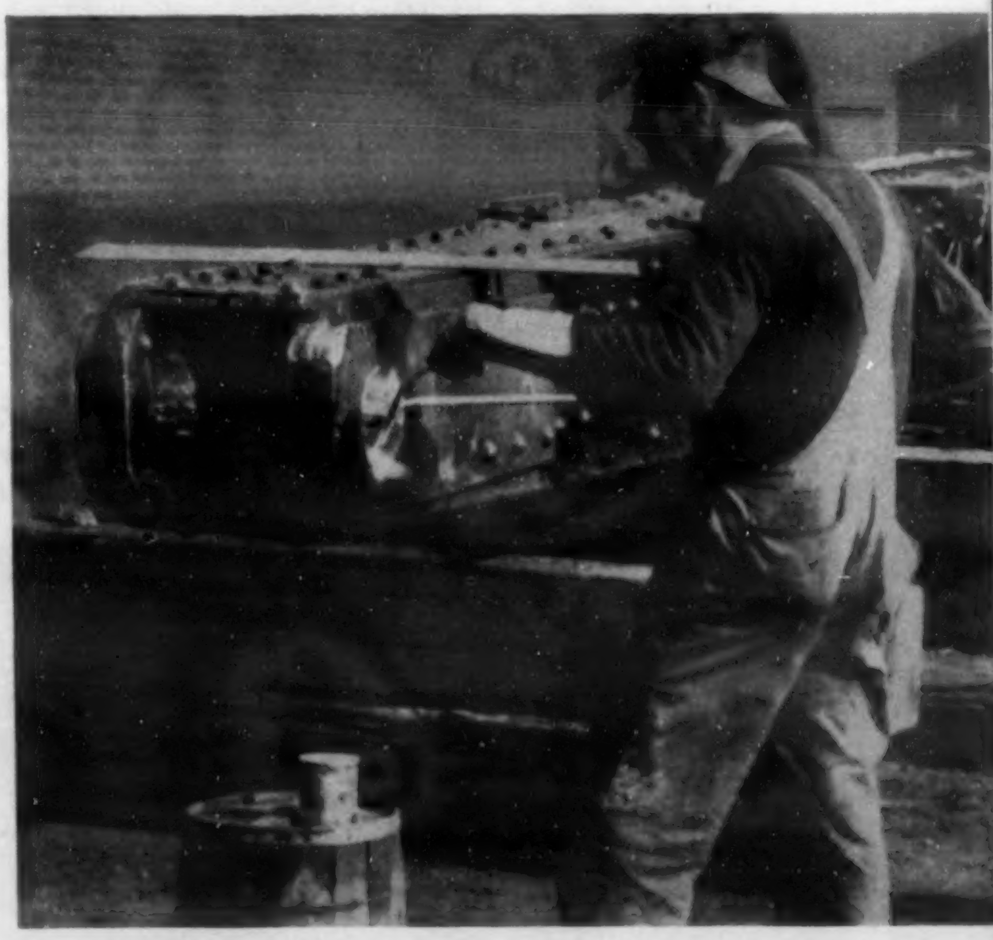
Bronze weld metal with its tensile strength of about 60,000 lbs. per sq. in. and ductility in excess of 30 per cent, greatly exceeds the tensile strength and ductility of cast iron. The rod metal bonds well with cast iron; the bond in fact, if properly made, being strong enough to pull cast iron away with it if a joint is tested to destruction.

One recent application of bronze-welding was its use for repairing the sabotaged engines of the Italian freighters seized in our harbors last April. The engines were rapidly repaired without removal from the ships.

Bronze-Surfacing Worn Parts

Just about as inevitable a problem as breakage in an industrial plant, is the problem of countering wear in moving parts or in surfaces that come in contact with moving parts. Tailor-made for this work is a development of bronze-welding known as

Rebuilding the worn surfaces of the shaft bearings in the end of this steel mast with a bronze welding rod.



"bronze-surfacing" which employs the same basic technique and rod as bronze-welding but differs from it in that it is employed not in joining broken parts but only as a means of adding metal to worn surfaces. This "building-up" process by bronze-surfacing has countless uses for plant maintenance. The free-flowing qualities of bronze rod makes it possible to apply it as a thin coating or to use it in building up comparatively thick sections of homogeneous metal. Bronze weld metal is readily machinable which means it can easily be machined to the desired dimensions after application.

Applications of bronze-surfacing are numerous. They include the rebuilding of such parts that are subject to wear in service as pistons, rotary valves, guides, and other moving surfaces of pumps, engine and machinery parts. Bronze-welding is equally useful for another operation that comes in the category of bronze-surfacing—the rebuilding of missing or worn parts, such as gear teeth or valve disks and seats.

The bronze-welding process is indeed a maintenance method of great versatility. Simple and economical in use, the process can fill a needed place in plant maintenance as long as parts continue to be subject to wear and breakage, and particularly in these days when speed and uninterrupted production are of such importance.

★ ★ ★

Many manufacturers have stepped-up production and eliminated bottle-necks due to material shortages by redesigning from metals into vulcanized fibre, laminated phenolic plastics, and laminated plastic fibre. About the only limit in machining or fabricating these non-metallics is the speed of the machines themselves.

—Continental Diamond Fibre Co.

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Screw Machine Products

by D. H. Montgomery

Vice President,
New Britain-Gridley Machine Div.,
New Britain Machine Co.,
New Britain, Conn.

That screw machines are capable of speeding the production of numerous metal products is so well understood that the makers of such machines are booked to capacity for many months ahead. Many thousands of screw machines are producing hundreds of screw machine products, both here and abroad, and the great problem at present is to find sufficient screw machine capacity to turn out these products in required volume.

Under these circumstances, perhaps the best comments which can be made in a short article may be in the form of suggestions or "rules" which, if followed, tend to simplify screw machine product manufacture and thus facilitate and help to speed the work which must be done. These rules are obvious to those who know screw machine work, but they are constantly overlooked, individually or collectively, with the result that work which might be speeded is often unnecessarily delayed. If those who design and purchase screw machine products will check them against this list, much time and cost will be saved:

1. Specify material which machines most freely and still meets other requirements so that machining time and tool grinding can be minimized. If possible, name one or more other materials or optional analyses which can be substituted if that preferred is not quickly available.
2. Design for a standard size of stock and the minimum size feasible, so that minimum depth of cut and minimum scrap will result and delays for obtaining special size stock can be avoided. Many odd sizes of hex stock now specified could, for example, be avoided.
3. If the piece must have a central hole, say one 60 per cent or more of the o.d., consider the possible use of tubing of standard size to avoid drilling either large or deep holes, with consequent scrap waste and slower machining, but allow for optional use of bar stock if tubing is not readily available.
4. Design for minimum difference between head or flange diameter and body diameter so as to minimize the depth of cut and the quantity of stock to be cut away.
5. Avoid designs which require special tools not easily made available, such as special taps or chasers, as these involve initial delays and production delays, particularly when breakage necessitates new tools.
6. Allow the widest dimensional tolerances feasible and never make them closer than required on mating parts. Close tolerances, though often essential, tend to slow production, often necessitating more down time for tool grinding and resetting, extra gaging operations and other delays.
7. Never specify No. 3 thread fits when No. 2 or coarser fits will meet requirements.
8. Design so that the number of operations required are minimized and so that as many as feasible can be completed in the screw machine or in some stock attachment readily available, unless, of course, more rapid production can be assured by transfer to a secondary machine known to be available.
9. Flange and other side faces, especially those to be cut by forming tools, preferably should not be required to make right angles (that is, be square) with the axis, as this usually makes necessary extra operations or additional tools, or both. Angles of 92 deg. *minimum* are preferred. A chamfer or radius at outer edges facilitates machining and may avoid extra operations.
10. Do not specify finishes smoother than that left by the usual finishing tool unless this be essential, in which latter case submit a sample showing the finish required. Unless burrs must be removed, do not so require. If required, specify where.

Of course, these rules are not all-inclusive or universally applicable, but their intelligent application will tend to speed production and often lower cost, in addition.

Die Castings

by Herbert Chase

Die castings are ideal for certain and numerous defense applications primarily because the die casting method is among the fastest and most efficient of production processes. Yet we find the American die casting industry using only a small fraction of its capacity for turning out defense items.

The two basic reasons are: (1) That the metals chiefly used, zinc and aluminum, are not plentiful, aluminum, in particular, being required for aircraft needs (in which, of course, some die castings are included). (2) That many of those in a position to make or dictate the use of die castings either fail to appreciate or to utilize them to best advantages or tend to lay undue stress on their limitations.

Both conditions doubtless will be corrected in due course. Although zinc is in great demand and will so continue, the shortage is much less acute than that of aluminum and the easing of non-defense applications, especially in die castings, should make ample supplies available for defense die castings.

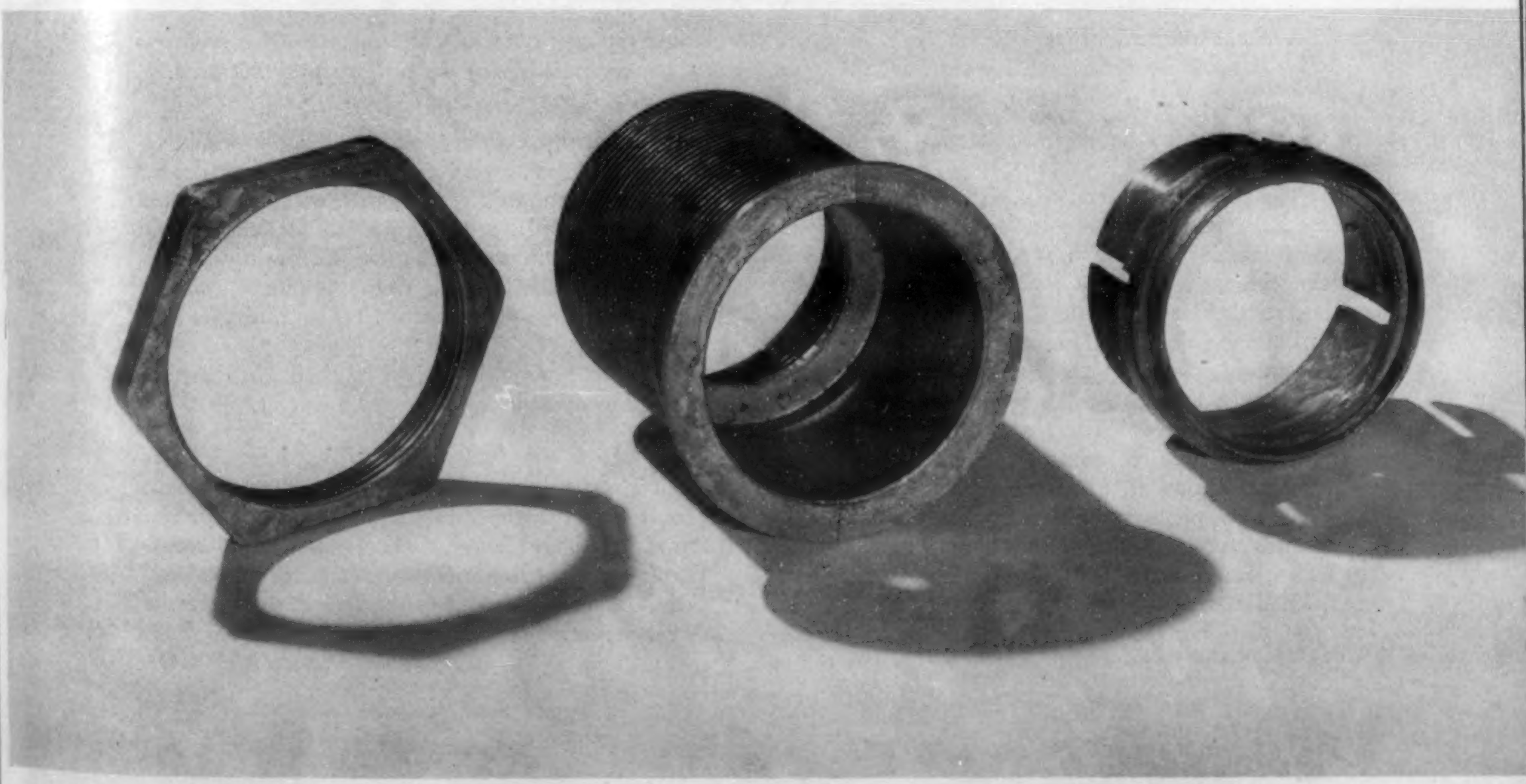
Many parts now produced on the screw machine, especially many made from brass, can be die cast in zinc alloy more rapidily and more economically and with no significant difference in performance. This will help to ease the extreme pressure for production of screw machine products (for which there are not now enough machines available) and will lower the demand for brass rod needed for purposes which the die casting cannot well fill. Some Canadian manufacturers have found this to be the case and are now die casting many fuse parts which were formerly turned from brass at a much slower rate and at much higher cost.

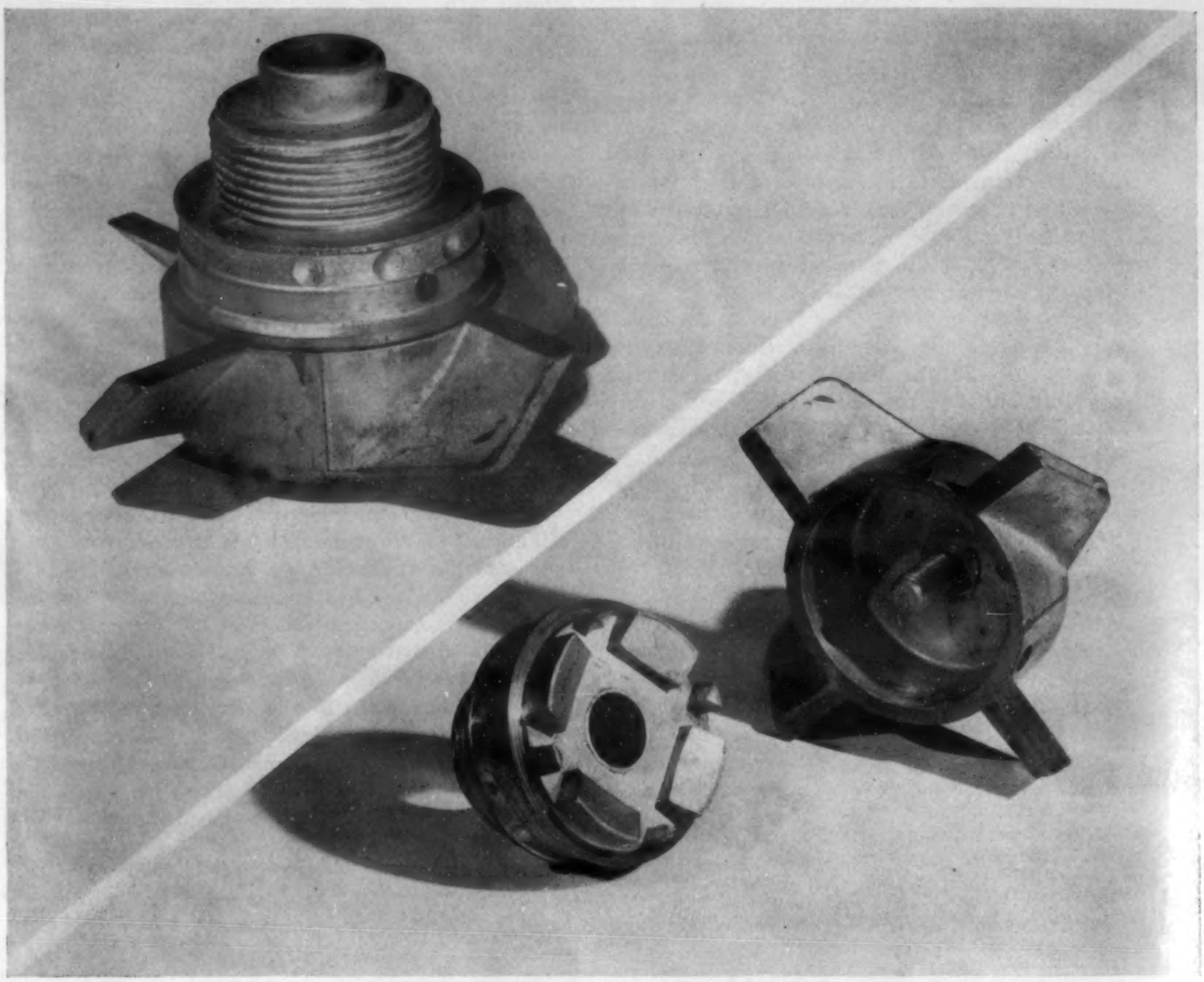
Numerous brass and aluminum castings, especially many now made in sand molds, as well as many iron sand castings could be converted to die castings in zinc alloy, also with great saving in time of production and, in all cases, with reduced labor and decreased demands for machine work, thus releasing skilled labor and numerous machines for other work, besides releasing some aluminum for aircraft uses.

There are also cases in which die castings yield definite economies, especially in labor, over stampings and plastic moldings, though space limitations prevent giving details here.

An accompanying illustration of three small zinc alloy die castings used for a certain form of emergency light, having Navy as well as civilian applications, gives an idea as to what can be done with die castings over alternative screw machine products. Some 1300 *sets* of these parts are made per 8-hr. day on a single die casting machine. Almost the only other operations required are to shear flash and

All three of these parts, for emergency lighting applications, are die cast with great economy and require almost no machining except for removal of flash and tapping the thread in the nut. Production by other means would cost much more in time and require many more machining operations besides involving much waste of metal.





These zinc alloy die castings for an aerial bomb are simply and rapidly produced and with marked economy as compared with the sand casting and the screw machine product required if die castings were not used.

to tap the thread in the nut, that on the male part being cast.

The two tubular parts could be made on the screw machine, but would require several operations and considerable waste of metal, as well as some re-chucking and relatively slow production. Secondary operations also would be needed, especially in cross drilling and slotting. The hex nut could be stamped, but would involve much waste of metal and would have to be tapped, besides requiring a separate die and separate press. There are three cavities in the casting die, one for each part, a single shot of the machine making all three castings.

Another photograph shows two zinc alloy die castings for a British aerial bomb, made in the United States. Two small unit dies, run simultaneously on the same machine, can produce 1700 pairs of these parts per 8-hr. day. One part could be produced on the screw machine at a much slower rate and with considerable waste metal but it would require supplementary milling operations not needed on the die casting. The other part, with vanes, would have to be sand cast if not die cast and then would need much machining. That the die casting is much faster and more economical to produce as well as better, besides requiring almost no machining is self-evident.

Many more examples might be cited, but these are enough to make the possibilities apparent.

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Non-metallic materials are being used in many cases as a substitute for "priority-bound" metals and alloys. This not only speeds up production where metals are almost unavailable, but facilitates fabrication in many instances by the elimination of the use of cutting oil.

—Continental Diamond Fibre Co.

Drop and Upset Forgings

by The Drop Forging Assn.

Cleveland

It is generally recognized that the use of drop and upset forgings is greatly facilitating the production of equipment for National Defense. Results of a brief survey among forging plants and users of forgings indicate that the adoption of certain specific practices could result in effecting further economies in the use of metal, substantially increase the rate of production and in many cases, step up the rate of machining and finishing of forgings.

Many of these practices are now being followed by manufacturers of drop and upset forgings, and their customers. These practices are mentioned for the purpose of *emphasizing* their importance, and to stimulate a more intensive effort on the part of those who may obtain still further benefits from forgings. Although, every production executive knows that drop and upset forgings, formed to close tolerances in closed dies, may be machined and finished at a faster rate, it is possible, that as a result of intensive application of these practices, a further increase in units per hour and per day, may be realized. Some of the specific practices which might be thoughtfully considered and applied are:

Check over designs of parts to be forged for the purpose of discovering any parts which might offer a further reduction in dead weight if redesigned. Since it is possible with forgings to get plus strength in lighter sectional thicknesses, metal bulk is usually a needless waste of metal. By designing parts which are to be forged, so as to avoid excess metal, a reduction of machining and finishing time can be effected.

Often the loss of considerable time could be avoided, if designers and engineers would consult forging engineers, about the problems of forging a specific part, to determine just what is possible and practical. When the prints of such parts are submitted to the forging plant, the prints are always turned over to the enginering department, which checks over the design of the part to be forged and the specifications for the forging, and determines whether the specifications, and other requirements can be met. If the requirements cannot be met, it is the forging engineer's job to show exactly what can be obtained, and to submit all changes that are necessary, to the customer for his approval. Obviously this requires considerable time. It is a sort of trial and error procedure. Furthermore, it is often necessary to redesign the parts. A great deal of time could be saved, and parts put into work much more quickly, by consultation with forging engineers preliminary to final designing of the part.

Check your specifications for steel from the standpoint of the physical values that you wish to obtain. Perhaps, you can get the same physical values from another grade of steel by subjecting it to heat treatment after forging. If so, give your forging source specifications to cover the use of whatever grades of steel are suitable. In many cases a delay, due to the unavailability of a certain grade of steel, can be avoided by substituting another grade of steel which, after heat treatment, will give approximately the same physical values. It may be possible to forge the part, at a faster rate, from a certain grade of steel, and with less wear on dies and equipment.

A designing engineer who is responsible for a large variety of forgings for heavy equipment suggests: The elimination of excess finish and weight in the original forging, *the adoption of precision hot punching and shearing practices, the coining of unmachined surfaces, the prevention of decarburization on surfaces subsequently hardened for wear resistance, the cutting down of wasteful flash and draft losses,* as methods whereby the production of forgings can be substantially increased, and machining and finishing operations greatly decreased.

It is also claimed that there are many opportunities to combine hot and cold forming operations to produce certain parts in a single operation, or in a series of operations by which abnormally high machining costs would otherwise be required. One instance of this sort was a bearing plate in which, by forging a developed piece in substantially a single plane, and then re-forming to shape, the draft and excess metal were so greatly reduced that the saving in the finished piece was 40% of the former method of forging and machining.

Many small forgings could be made without scaling by changes in heating methods, thus eliminating pickling and cleaning. Induction heating with atmosphere control has been applied in some isolated instances. Atmosphere control of heating in large sizes of forgings to limit the scale and prevent decarburization would justify greatly reduced finish allowances, and in many instances avoid finish at all.

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By arc welding heavy flame-cut plates, costly castings can be eliminated in many cases. Where old and worn out castings require replacement, the welding method of fabrication speeds construction.

—Hobart Brothers Co.

★ ★ ★

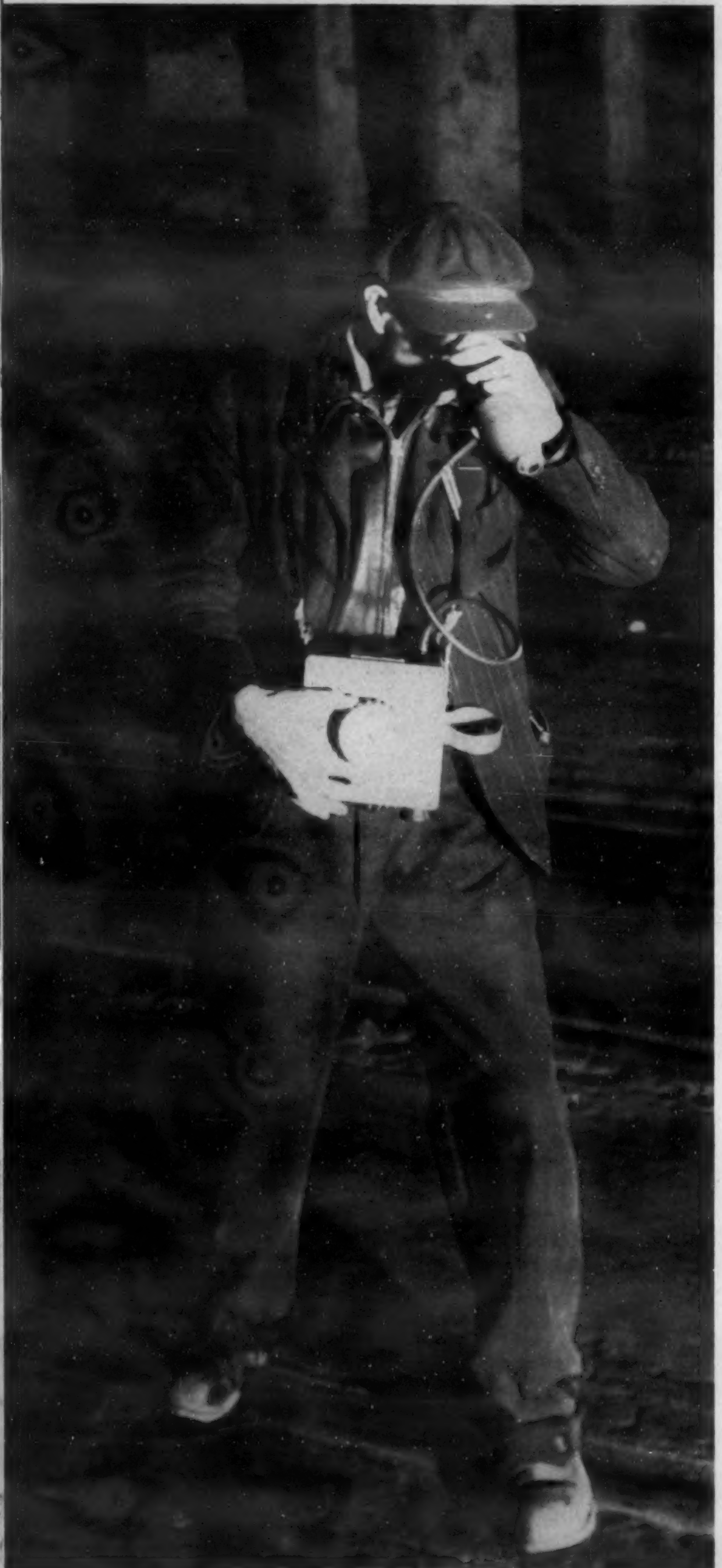
Shortages of chromium and nickel are being offset by the use of stainless-clad steels, which make the chromium and nickel go 5 times as far. The cladding is 20 per cent of the plate or sheet, has equal corrosion resistance, and saves up to 45 per cent in material costs.

—Jessop Steel Co.


CURTISS
INSPECTION
INSPECTOR

FASTER PRODUCTION

—INSPECTION AND TESTING



Measuring temperatures of molten steel with an optical pyrometer. (Courtesy: Leeds & Northrup)

National Defense Materials

by G. F. Jenks

Colonel, Ordnance Dept., U. S. Army, Washington, D. C.
(Approved by the War Dept. for Publication)

In the conversion of production to National Defense matériel, industries are being developed to tenfold and even hundredfold of their former capacities. Many units of these industries are manufacturing a product with which they have had no previous experience. These and other conditions have resulted in serious problems in recruiting and training inspectors. Both the recruitment and the training programs are difficult because so few have a knowledge of the conditions of use and requirements of military products.

The inspector needs to possess a knowledge of materials and processing methods and of the functioning and service requirements of the final product. The service conditions of use, and the type and magnitude of stresses should be known in detail for each product. This knowledge is far more important for military matériel than for ordinary industrial products as there are for the former so few traditions and customs in the mill and the shop. The problems of inspection may well be solved by going back to fundamentals and applying rational thinking.

The suitability of a material for a given product depends, to a large degree, upon the process of fabrication. In many cases, the quality factor is fixed by the conditions and strains of processing rather than by the service use of the final product. For example, the requirements for forging quality or deep drawing quality are definite in respect to permissible defects and irregularities of structure and surface. A requirement for welding quality is definite in respect to composition as well as to defects and irregularities.

The conditions of use have likewise been used to express quality factors. Ordnance quality has long had a definite meaning in some of our steel plants. Aircraft quality is a newer term but of more exacting requirements. High temperature or low temperature service bears definite significance as to composition and methods of deoxidation; shell steel has a definite meaning as to internal and surface structures.

Intelligent decisions on the suitability of materials to meet the intent of the design engineer's specifications and to behave satisfactorily during subsequent processing operations depend both upon a knowledge of the normal properties and structure of materials and of their defects and irregularities. Our engineering materials are neither homogeneous nor uniform. Looked at with the eye only they may appear to be homogeneous and free from defects and irregularities. Viewed under the microscope an en-

tirely different picture is presented and it is this more sensitive view that must be considered in judging the suitability of materials.

Long engineering experience in studying the behavior of materials has given us a high degree of confidence in the behavior of normal materials. We have had premature failures and a science has been built up which correlates such failures with deficiencies both of design and of material. Under certain conditions we have learned to judge whether irregularities of structure and surface are harmful. Similarly, we have been able to correlate these irregularities of material with successes and failure in processing methods.

For a decision as to whether materials are abnormal, the inspector should know what defects and irregularities of structure are permissible for various products or classes of semi-fabricated parts. He needs to know the structure of the ingot for the various classes of steel and types of molds and how the irregularities and defects of structure are modified in subsequent operations. He needs, of course, the additional knowledge of the influence of those irregularities upon the behavior of material when subjected to the strains of subsequent processing and to service loading and stress concentrations incidental thereto.

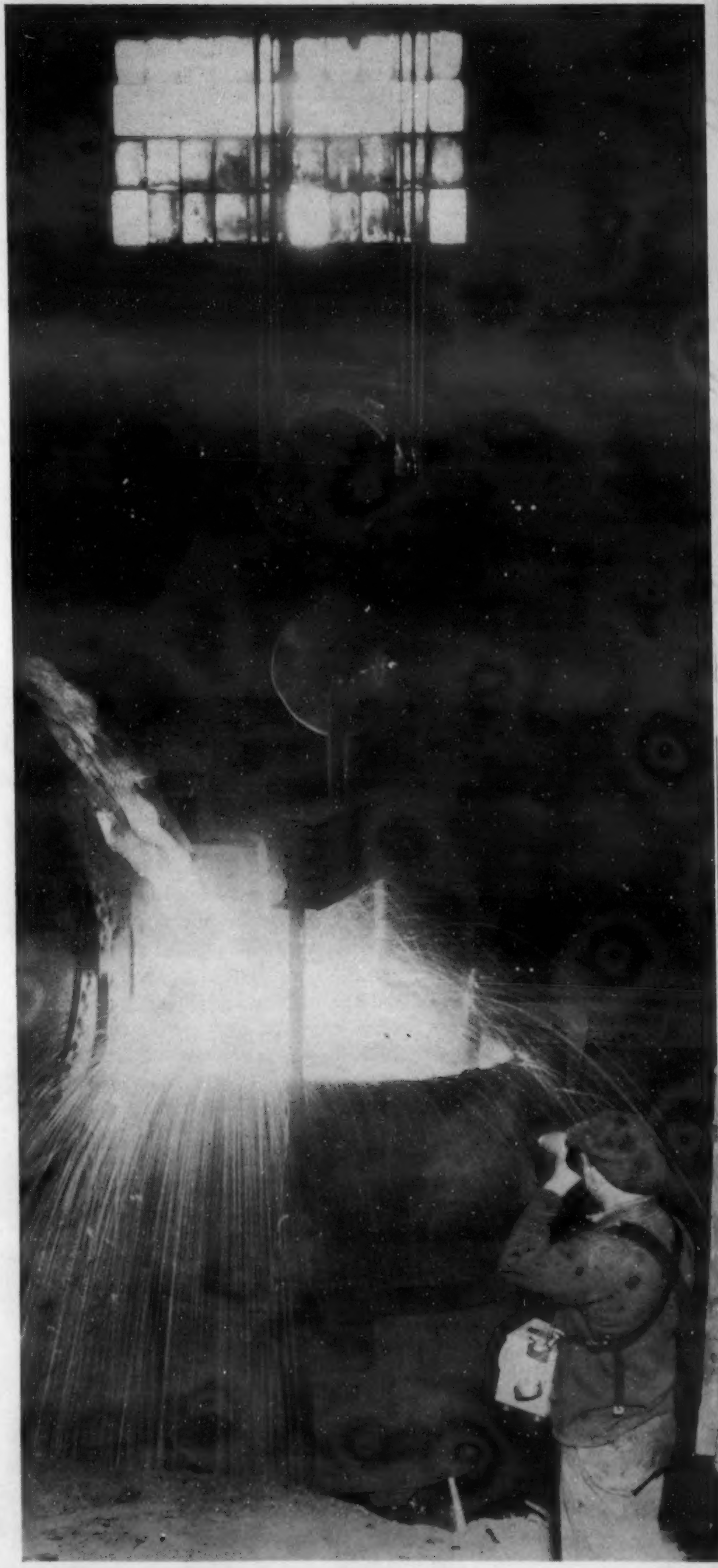
Ordinarily, an inspector obtains this knowledge of mill inspection practice through long experience and from the traditions of the mill handed down from prior generations. There is little literature on the subject. The absence of a literature makes the training of inspectors more difficult and increases the probability of condemning materials which may be suitable.

There is need of a basic text book on the subject of the defects and irregularities of structure and surface of metals. Such a text should treat of the ingot, describe its limitations and trace its defects and irregularities back to their source. It should give complete details of these defects and irregularities in the billet, bar, and plate. It should describe their significance in respect to subsequent processing and to various types of use of the material. Such a text would require the collection, analysis and editing of a vast amount of practical experience. It would be of inestimable value in times like these when so many inspectors must be trained for new products.

★ ★ ★

A magnetic gage, accurate to 1/1000 of an in., is available for rapid measurement of the thickness of any magnetic sheet or plate as long as the material is not backed by other magnetic material. The gage is especially valuable for checking the center and other points on wide sheets of steel where the use of calipers is inconvenient or impossible.

—General Electric Co.



Pig iron being poured from a hot metal ladle car. Its temperature is taken with a potentiometer type optical pyrometer. (Courtesy: Leeds & Northrup)

Specifications and Standardization

by Francis G. Jenkins

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1st Lieut., Ordnance Dept.,
Watertown Arsenal,
Watertown, Mass.*

This article is a condensation of a more extensive discussion of principles advocated by the Arsenal for the drawing of specifications. Industrial readers should find in it much to help them in the preparation of specifications that are simultaneously clear and expeditious.—The Editors.

The strong trend in recent years toward standardization, aided and abetted by the growing influence of the A. S. A. and the A. S. T. M., has benefitted not only the relations between industrial seller and buyer but has effected as well important savings in time, money and convenience together with improvements in product quality and reliability.

The preparation of the material specifications that are the foundation-stones of standardization can also be accomplished in each case with an eye to the elimination of all possible delay in "understanding" the material, in production, and in acceptance testing. Thus, in setting forth requirements, emphasis should be on satisfactory performance in service and in fabrication rather than on method of manufacture, chemical composition and physical properties.

Time and trouble will be saved by making the requirements of a specification definite and exact. Numerical expressions of values should be used, since these are susceptible of measurement or comparison, and thus leave little room for misunderstanding.

Consumer specifications should be formulated on the basis of the foundation laid down by technical society or governmental bureau specifications. National standards of this type are evolved through the collective work of leading experts and as such are more valuable than might be the selection of one individual in one plant.

Furthermore, by utilizing a standard specification, the advantages of simplification are secured. By concentrating attention on one standard material of a kind, production is possible in larger quantities at lower cost, and better facilities are afforded for manufacturing, inspection and testing.

The producer should be given the greatest possible latitude in furnishing material for the purpose desired. Unnecessarily severe requirements hurt both the producer and consumer, since they increase the cost and tie up production through delays in shipment. Recognition of the seller's point of view is an essential in making the specification effective. No amount of specifications can replace mutual respect and good feeling between seller and buyer.

Tolerances

Tolerances should be wide enough to accommodate uncertainties of test methods. Special care must also be taken that the specification does not "overspecify" by requiring material that is actually too good for the buyer's purpose. Also, requirements should never be written around one particular brand of product; for example, composition ranges for tool steels should be sufficiently broad to include in any one group most of the proprietary brands that are intended to be similar, and yet sufficiently restrictive that heat treatments, applications and general characteristics would be identical for any steel meeting the specification.

In general, reduction in tolerances increases costs, limits the number of supply-sources and extends the time required for testing.

Form of Specification

A specification that follows a standardized form tends to eliminate confusion in its use, as familiar and oft-applied requirements are found where expected. Adherence to a definite sequence also may assure the inclusion of important details that would be otherwise overlooked by the specification writer.

The so-called consolidated specifications are desirably comprehensive and incorporate several grades, sizes, tempers, etc. of one broad class or similar composition of material wherever feasible, each being identified by a numerical suffix. Such specifications eliminate the repetition of dimensions, ratings and general instructions, and the greatly-reduced number of papers to be handled thus requires less clerical effort.

The author has found the following practice quite satisfactory. The principal sections are grouped under suitable headings, which appear in capitals, are underscored and may be designated by arabic numerals, numbered continuously. Sub-sections within a single section are preceded by sub-headings, which are capitalized, underscored and set off by lower case letters in parentheses.

The requirements are generally grouped under the following section headings in the sequence indicated:

Scope
Applicable requirements
Manufacture
Chemical requirements
Physical requirements
Form and size
Size tolerances
Packing
Marking
Rejection

Most of these require no explanation here as to their contents, although a few comments may be of help. Thus "Form and Size" covers the form of the material (strips, bars, tubing, forging, casting, etc.) and the acceptable size, including length, weight,

coil diameter, etc. In a factory where storage and machine room is limited, it is often out of the question to accept bars above a certain length, as they would have to be cropped short prior to storing or machine, thus necessitating an extra operation and modifying the cost figure.

★ ★ ★

A rapid and precise means of studying spectrographic plates can be had through the use of a photometer. The instrument enlarges the spectral lines approximately 20 times.

—General Electric Co.

★ ★ ★

Magnetic Powder Testing

by A. V. de Forest

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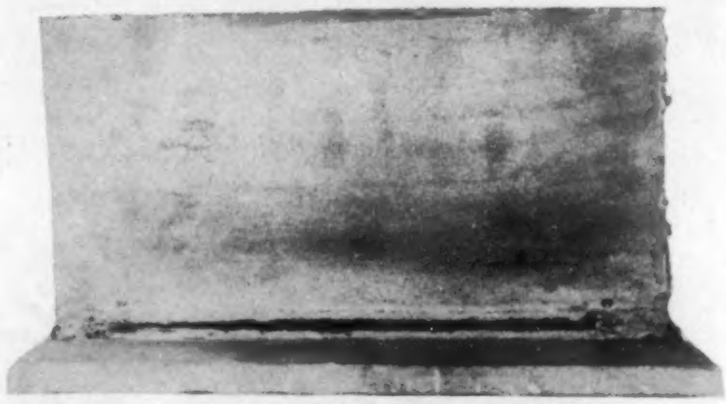
Massachusetts Institute of Technology,
Cambridge, Mass.

The magnetic test for local defects developed by the Magnaflux Corp. has been in active use for only 10 yrs. Originating in a method primarily designed for finding surface cracks, particularly those due to fatigue, grinding and quenching, the most recent developments of the method lie in the very different field of locating non-metallic inclusions in raw materials as well as finished parts.

The colloquial term "dirty" steel requires some method of estimating the various varieties of dirt before specifications covering clean steel can be written. Dirt has been defined as "matter out of place," and nowhere is this definition more apt than when applied to non-metallics in steel. Matter most carefully introduced into free machining screw stock is dirt despicable in tool steel and worse yet in ball-bearing steel. In fact, dirt control is much of the art of steel making, and mechanical testing is the proof of the pudding.

The nature and distribution of non-metallics has mostly been studied by micro examination of the small particles and macro inspection of the gross distribution after a deep etch. Both of these methods of examination are restricted to small areas; in the case of the micro inspection to such infinitesimal samples that only the uniformly distributed non-metallics can be reliably detected. Deep etch specimens from each end on billets and forging bars are more representative, but the larger the aggregations of non-metallics, the less uniform is their distribution, and the larger the necessary sample to obtain an accurate rating for the quality of steel. Finally, the entire philosophy of rating becomes absurd when, out of 100 forgings from a single bar, only one contains a rejectable defect. Rejection of the entire bar,

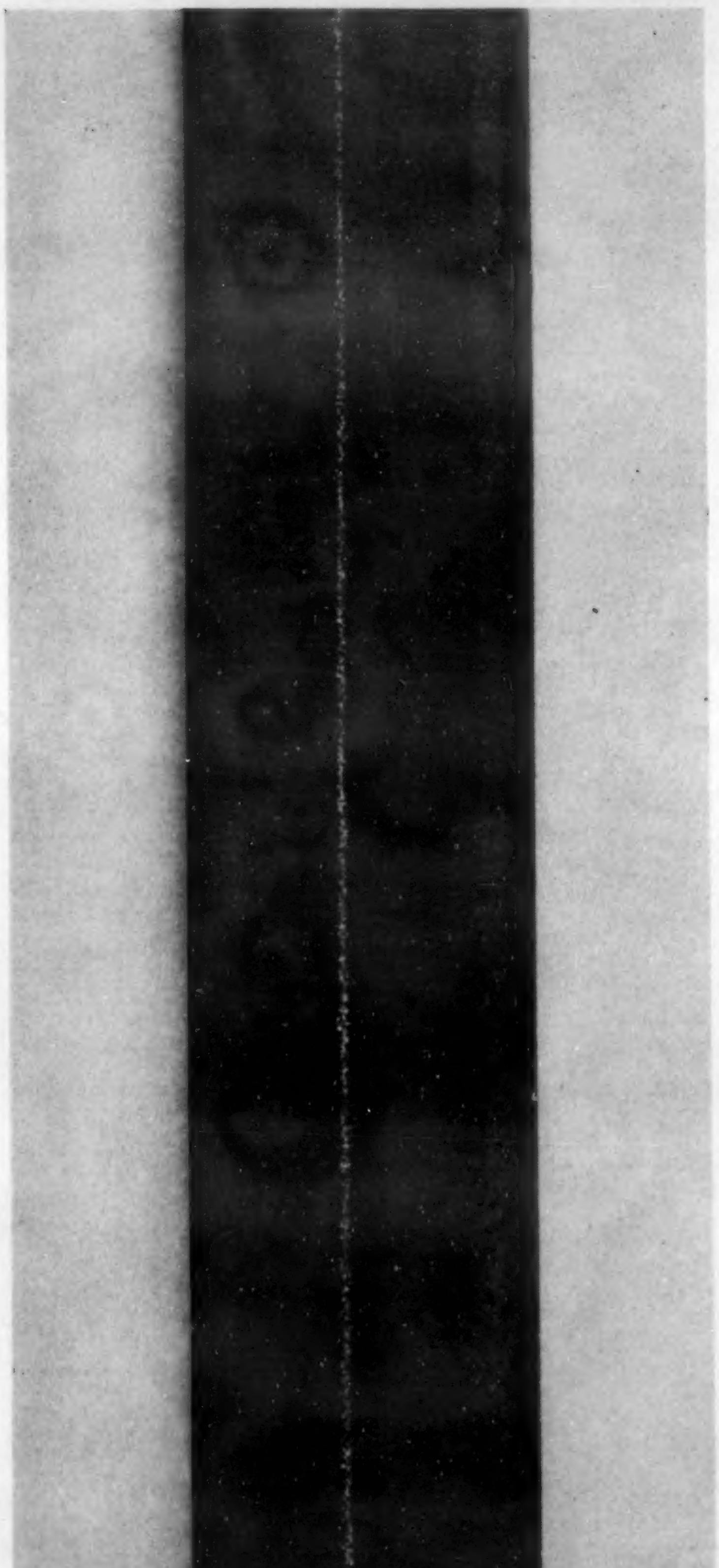
Small heat-treating cracks in a connecting rod.



Deep seated defect in a fillet weld.

Fatigue cracks in a railroad spring.

A seam in bar stock.



if the one defective spot were taken as a criterion of quality, is too wantonly wasteful even for peacetime procedure.

Fortunately, the Magnaflux method of test has shown that in numberless cases of incipient fatigue cracks the cause lay in design of the part, the choice of the steel and its treatment, defective surfaces and corrosion, rather than in dirty steel. Under the leadership of the Society of Automotive Engineers, Iron and Steel Committee, Subdivision on Magnaflux Rating, L. A. Danse, chairman, the Magnaflux test has been applied to the problem of specifying aircraft quality steel. A test specimen of appropriate length and diameter is magnetized by a standard current passing through the part for a limited time and a standard concentration of indicating fluid is flowed over the specimen. Any longitudinal inhomogeneities are clearly shown and may be rated as to number, size, and distribution. A further magnetic inspection of each piece after manufacture is complete may be depended upon to eliminate any part in which a dangerous defect appears.

The decision as to rejectable limits for the raw steel will depend on the number of rejections of the finished parts and the cost of manufacture. Thus, for maximum economy of steel, no arbitrary limits of acceptability need be set down if there is agreement as to the rejection limits in the finished part. The difficult question arises in reaching the latter decision. It is now far easier to locate non-metallics than to evaluate their effect on the mechanical strength of parts in service but fortunately it is also becoming generally recognized that non-metallic inclusions act only as stress raisers and their effect is small as compared with insufficient fillets, corners of key ways, and oil holes. In this connection the book entitled, "Prevention of Fatigue of Metals" by Battelle Memorial Institute is highly recommended. Also their danger depends on being near the surface where they are easily located, and on their direction in relation to the applied stress. Fortunately again, in very many cases the stress direction follows the grain flow of the steel and hence the longitudinal axis of the inclusions.

The necessity for knowledge rather than prejudice in setting rejection limits is now better appreciated; and due to the scarcity of steel, manufacturers of finished parts are more hesitant about unwarranted rejections. The S.A.E. committee on inclusions in steel, and the A.S.T.M. Committee on Metallography are both considering this subject. The desire for deliveries on the part of customers, particularly the Government services, is exerting an increasing influence on more intelligent and flexible inspection. The wasteful rejection of past methods was primarily based on fear of unknown defects.

Magnetic powder testing has demonstrated its ability to show exactly what inhomogeneities are present in the vital surface region of steel parts, and the way is now open for test engineers to prove by laboratory and field tests and repeated inspection what conditions are in fact, rather than in fancy, sufficiently dangerous to warrant the waste and delay of rejection. When parts rather than small specimens are adequately designed and tested, some present-day fears of necessarily heterogeneous steel will be regarded as outmoded superstitution.

Metallographic Inspection

by Tracy C. Jarrett

Chief Metallurgist,
Koppers Co., Amer. Hammered
Ring Piston Div.,
Baltimore, Md.

The inspection of both raw and finished materials is of vital importance to our National Defense. *The training of men who can polish specimens by hand is one of the big metallurgical bottlenecks in the inspection of specimens.* It is the author's purpose to present a brief outline to speed up the preparation of metallurgical specimens for macro and micro examination without decreasing the quality.

1. Know what the specimen is to be inspected for.
2. Supplier and user should reach an agreement as to what information the examination is to give. Where possible, follow A.S.T.M. standards and methods.
3. Select proper sample and thus eliminate resampling and extra specimen preparation.
4. Use proper method for cutting-off specimen. It is suggested that cut-off wheels be used and this be done under water to prevent burning and disturbing the surface to be examined. If cut-off wheels properly mounted and consisting of the correct grade and bond are used, a cut surface ready for mounting and polishing will be produced.
5. Mount the properly-cut specimen in hard bakelite or prepared holders prior to polishing. This tends to prevent rounding the edges of the specimen and keeps the specimen flatter. *Bakelite mountings are preferred to transparent thermoplastic mountings, particularly where speed and quality are concerned.* If the electrolytic method is used, mounting in organic materials is not recommended.
6. Select proper polishing method. The properly mounted specimen which is now ready for polishing can be prepared for microscopic examination by several methods. The conventional hand method of polishing has been described by other authors, and a list of their publications can be found in the bibliography. A method that standardizes the polishing of specimens will be described. This method is fast and non-technical and can be used without the use of a highly trained man.

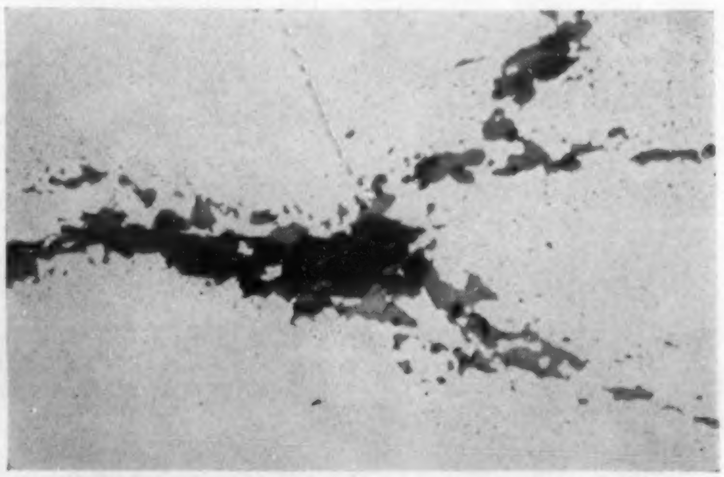
In the writer's experience the method of "Grind-Polishing," as outlined below, produces specimens of uniformly high quality with maximum speed and least dependence on the human element.

Using a commercially available polishing machine especially designed for the purpose, six 1¼-in. mounts can be prepared at one time using the following procedure with fixed abrasive wheels:

1. Rough grinding of specimens using 500 grit stone.
2. Fine grinding of specimens using Levigated alumina stone.
3. Semi-"Grind-Polishing" of specimens using impregnated wax cloth lap.
4. Final-"Grind-Polishing" of specimens using pressed felt lap.

This entire cycle can be performed in approximately ½ hr., using standard prepared solutions for the above four operations. This standard technique has worked successfully for both non-ferrous and ferrous metals. *The above operations tend to eliminate the human element.*

The polishing lap and specimen holder, showing the driving spindle for the holder, the solution reservoir and the stirring rod of the described standard method. The "grind polishing" of the specimens is produced by using light loads and slow speeds.



In "grind polishing," inclusions are held in place. Pitting and flow of metal is minimized. Specimens are flat and relatively free from scratches.

A few hints that tend to help in the preparation of specimens are:

1. *Do as little work on a specimen as possible,* but sufficient for the purpose at hand.
2. *Round the edges of the mounted specimen to be polished.* This helps the flow of polishing solution between the surface being polished and the lap.
3. Copper or nickel electro-plate small specimens whose edges must be accurately preserved.
4. Do not use a large specimen when a small one will serve the purpose. *Polishing a large specimen takes time.*
5. Do not permit any carry-over of abrasive material to succeeding operation. *Absolute cleanliness at all times is essential.*
6. Group a number of specimens in the same mounting when conditions permit.

Observance of the suggestions outlined makes possible the polishing of metallurgical specimens very quickly without decreasing the quality of the finished surface.

Some articles, books and charts on the preparation of specimens for metallographic examination, to which the reader's attention is invited, are listed in the bibliography.

[1] "Metallographers Handbook of Etching," Torkel Bergland, Isaac Pitman and Sons, New York, 1931.

[2] "Inclusions in Steel," C. R. Wohrman, American Society for Metals.

[3] "Metallographic Technique for Steel," J. R. Vilella, American Society for Metals, Cleveland, 1938.

[4] "Photomicrographs of Iron and Steel," E. L. Reed, John Wiley and Sons, New York, 1929.

[5] "On the Preparation of Iron and Steel Specimens and Microscopic Investigation," *Trans. American Society for Metals*, Vol. 24, Mar. 1936, pages 1-25.

[6] "Metals Handbook," American Society for Metals, Cleveland, 1939.

[7] "A Method of Preparation of Metallographic Specimens," G. Ellinger and J. Acken, American Society for Metals, *Preprint* No. 22, 1938, 15 pages.

[8] "Physical Metallurgy Laboratory Manual," N. E. Woldman, John Wiley and Sons, New York, 1930.

Welding-Quality Steel

by S. L. Hoyt and C. B. Voldrich

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Battelle Memorial Institute,
Columbus, Ohio

Large tonnages of steel, with 0.25 per cent C and under, have been fabricated in the past decade or so by the new methods of welding. This is an excellent quality of steel for this purpose and, as compared to riveting, has affected the requirements placed on the steel mill in two ways. Scarfing and welding magnify the significance of impurities and defects, which riveting could ignore, which may necessitate much repair welding or even the rejection of the plate. Welding has also increased the use of heavy plates so the mill must combine good rolling quality in

Solid alloy process vessel in course of construction. (Courtesy: A. O. Smith Corp.)

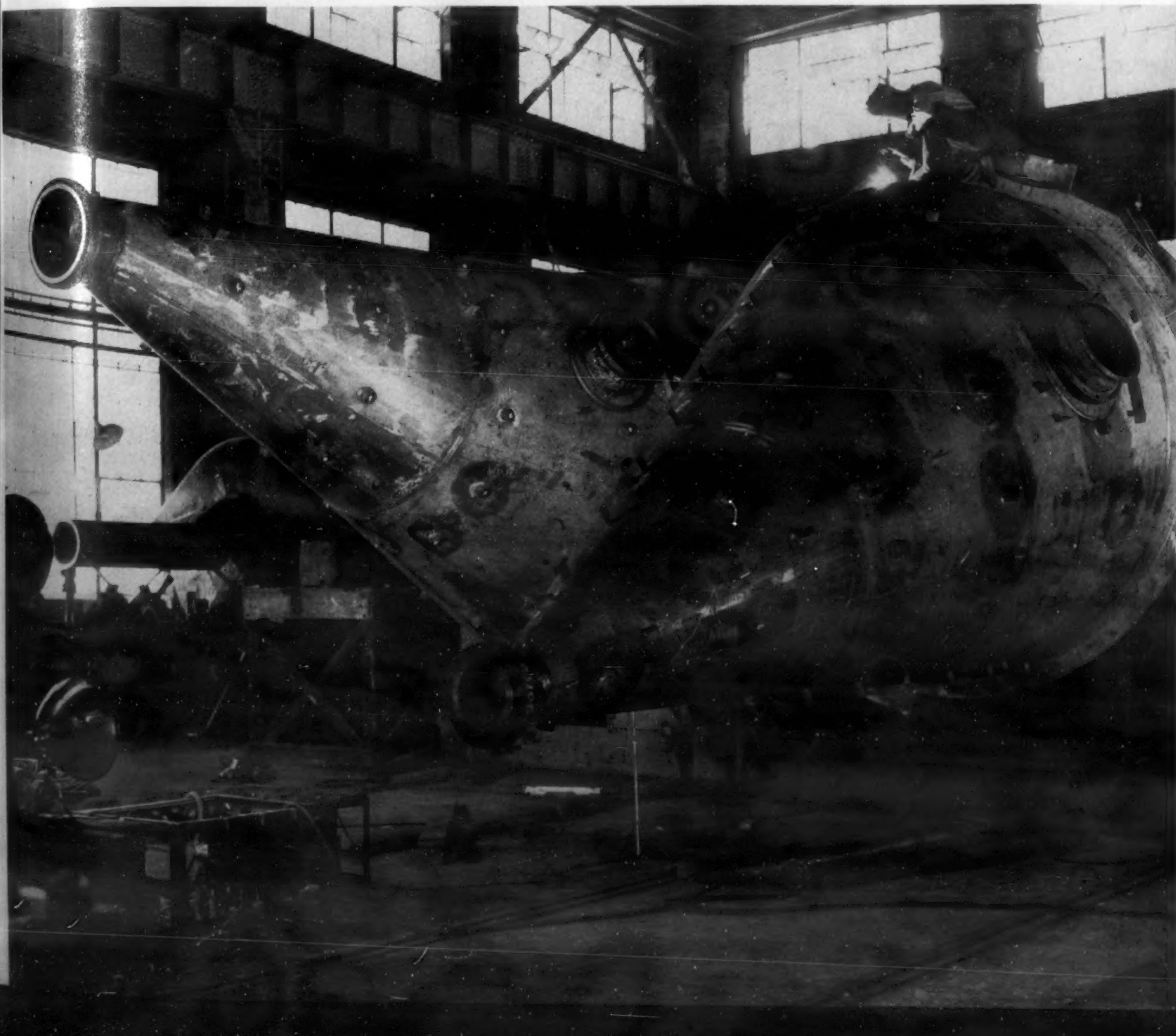
large ingots with the requirements of the designing engineer and the welder.

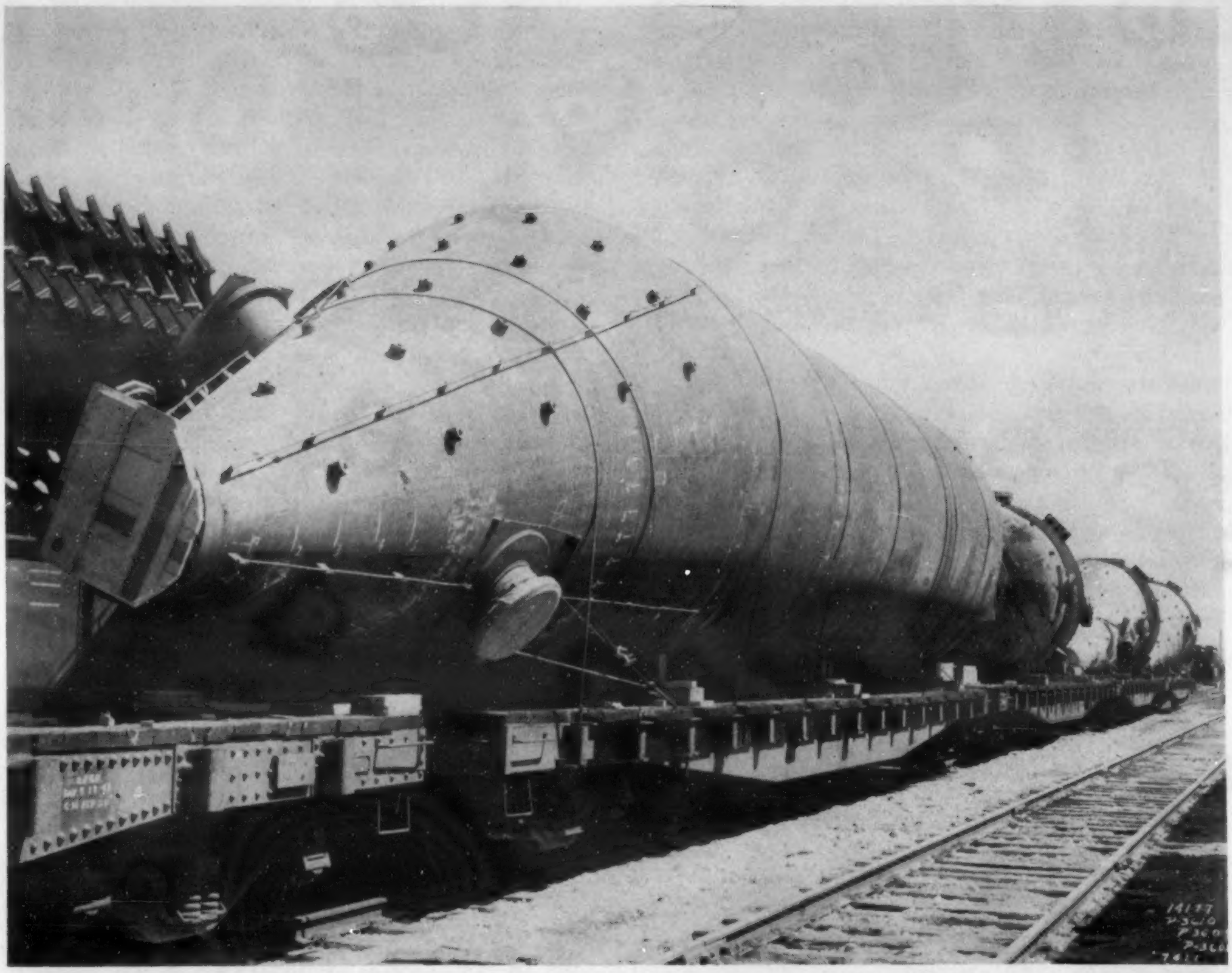
This swing to welding has fortunately occurred at a time when important improvements in steel making were being introduced—such as the scientific study of open-hearth operations, the installation of high speed rolling mills, vastly extended technological control of all operations, etc. Though specifications have been used in the purchase of the steel, and we are well aware of their place in industry, it has been the close cooperation between steel mill and fabricator that has given the welding industry its important raw materials of the necessary quality and at a price that promoted expansion.

The designing engineer has been quick to appreciate the greater possibilities of welded construction and is now calling for steels which come above the range of common carbon steel. The greater strength calls for higher carbons or for the use of alloying elements and the fabricator is confronted with the problem of what steels to use and how to write his specifications. Outside of costs the problem centers around securing the properties required by the engineer and the fabricator and also getting the level of weldability required for the welding conditions which have been laid out for the job. Commercial tolerances for the more important chemical elements are established but the "natural" ranges for welded fabrication may differ from those set up by previous specification practice. The fabricator may have to take one chance of getting the carbon and alloying elements on the high side at a sacrifice of weldability and another chance of not having them high enough for strength. The impurity elements, sulphur, phosphorous, oxygen, nitrogen, hydrogen, etc. offer additional problems.

Finally the engineer may set up additional requirements, especially if the steel is to be heat treated or must have some particular characteristic. This may be illustrated by the case of molybdenum steel used for

Other solid alloy process vessels being constructed. They are typical of the giant stainless lined vessels for the oil, paper and chemical industries. (Courtesy: A. O. Smith Corp.)





Solid alloy process vessels ready for shipment. They illustrate the flexibility in design and relative freedom from size limitations made possible by welded fabrication. (Courtesy: A. O. Smith Corp.)

high temperature service. The engineer may wish to have the molybdenum on the high side and may also ask for silicon-killing, these factors being involved in high temperature behavior. The fabricator may look askance at this kind of steel, particularly if the carbon and manganese happen to come on the high side, while the steel mill may feel its hands are tied in too many ways since it already has to meet its own problems and those of the fabricator.

Without being able to consider all the points of this complex problem of specifying steel for welded fabrication, we have tried to indicate something of its nature. Obviously the individual case controls the requirements for weldability and no general rules can be written until the situation is more thoroughly analyzed and much better understood. There would be considerable merit in the suggestion that the steel mills simply supply steel "to make the part," but it is doubtful if this would be practicable with the multiple responsibilities involved. Someone must select a steel to suit fabrication and service; someone else must set up and supervise correct fabrication and inspection; and the residual responsibility must be assumed by the steel mill to furnish the correct steel.

The control of welding operations varies materially with the type of job, equipment, experience of the staff, etc. Until more positive control of "weldability" is secured, a certain amount of give and take is needed. The welder should use his "tolerances" (preheating, welding conditions, etc.) to compensate the natural or unavoidable variation of the steel. The steel mill, in turn, with its improved technique should hold those variations to a practical minimum.

★ ★ ★

Timers and time switches save time. They speed up production by keeping operations going automatically, and leave the operator free for other work. Time switches allow heating operations to begin before the workday starts and continue after it closes.
—General Electric Co.

Instrumentation

by C. O. Fairchild

Director of Research,
C. J. Tagliabue Mfg. Co.,
Brooklyn.

While it may be the case that a single specific and practical idea for applying or improving instrumentation can increase and improve production in some bottle-neck, it appears to this writer that more widespread improvement would derive from a set of facts and principles having general usefulness.

As a simple example of this point of view, the protection tube for a thermocouple is chosen often on the basis of lowest cost figured in months of service per dollar, without perhaps counting the short delay in production which may accompany a replacement; instead, in the present emergency, the tube should be chosen for longest life and maintenance of the accuracy of the thermocouple. On the other hand, if replacing a thermocouple does not stop or slow production for a minute, more or better production may result from removing the protecting tube, at the expense of spoiling the couple in one week instead of eight.

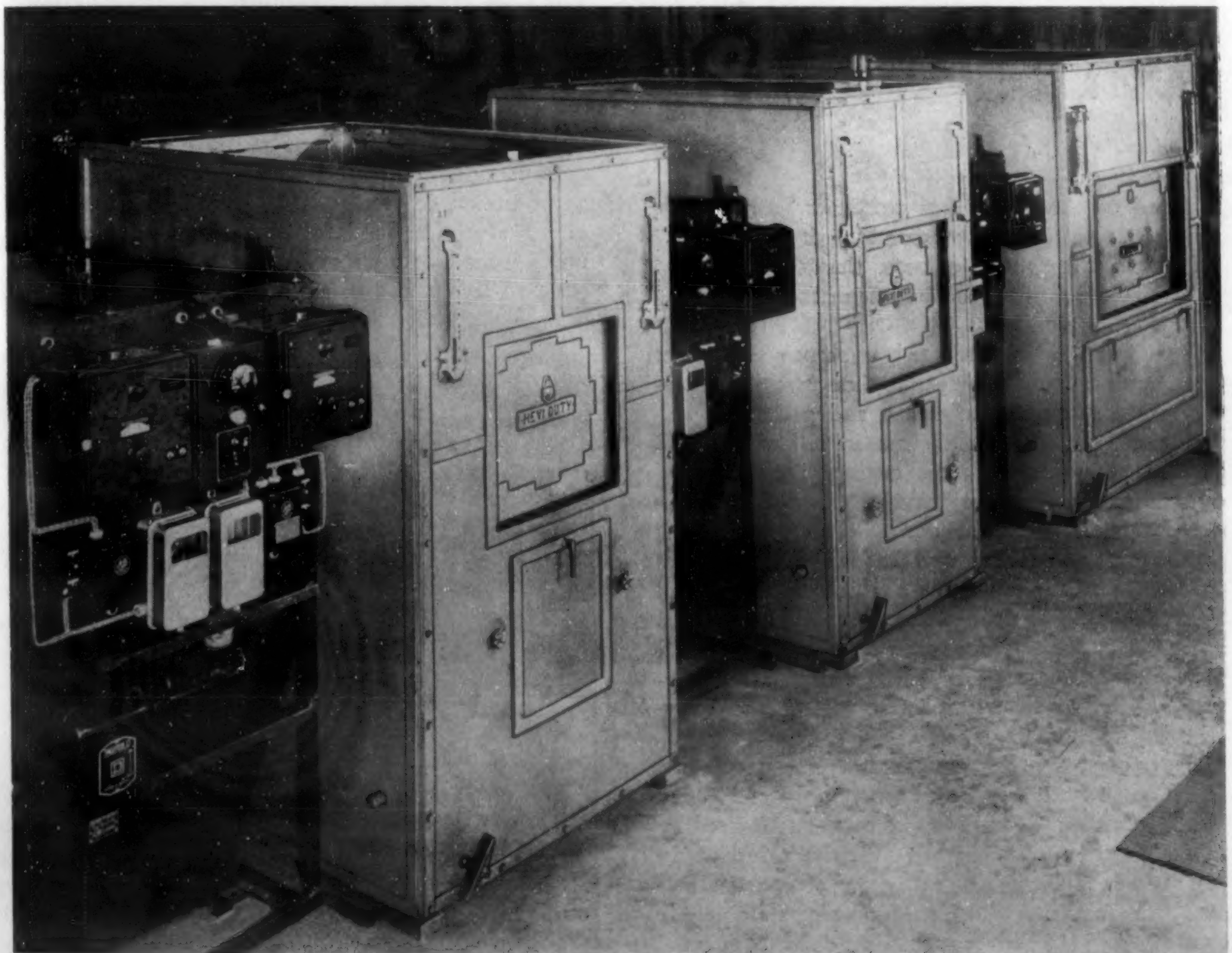
In submitting an itemized list of suggestions, in the hope that each reader might perchance find one item that has not hitherto come to mind, one must realize that there are hundreds of men in speeded-up plants, working day and night to keep up the pace, and finding their minds wracked while they try to sleep, with tumbling ideas for speed—speed. We do not presume to offer any better ideas, but only to gamble on the chance that one was missed.

1. The practice of any economy in instrumentation, that can slow up production, or lower the quality of the product, would seem to be questionable.

2. Every industrial instrument now installed and in use should be put in tune with the times. It should be put in A1-A running condition so that it will measure and record accurately and control well within the limits for which it is designed. It is not debatable whether such effort will improve production.

3. Instrumentation, particularly in all of the metals industries, should be increased to the limit of the capacity of the instrument manufacturers, and in these industries, this means fully automatic control of all processes.

An installation of indicating potentiometer controllers on electric heat-treating furnaces.



4. A spare instrument should be available wherever a failure may mean a loss in production.

5. Maintenance men should be available *at the factory* during all running hours. In the smaller shops not affording instrument maintenance staffs, the instrument manufacturers' service men should be called regularly on a contract basis.

6. The full benefit of instrumentation requires that inspection departments be cleared of all delay, and inspectors placed at all strategic points *in production departments,* where they can warn of conditions causing rejections as soon as possible. In spite of bottle-necks in handling material, lots should be scrupulously kept intact so that causes for rejections can be expeditiously run down.

7. Whenever new instruments are being ordered, standard designs should be specified, not special in any way even as to scale range, unless the special feature is as urgently required as any item assigned an A1-A priority. Time will be saved if purchasing agents are provided with alternatives along with the original requisitions.

Instruments and the materials required for their manufacture should have the highest priority, at least until the plant expansion program is almost finished, and readers are urged to support this point of view. Experience of engineers in the metal industries makes them especially well informed as to the facts bearing on this matter.

Mass Radiographic Inspection

by Robert C. Woods

Physicist,
Bell Aircraft Corp.,
Buffalo, N. Y.

Based on the quantity of work now done by the average industrial X-ray laboratory, it appears safe to assume that the use of more than 500 sq. ft. of X-ray film per day constitutes mass radiographic inspection.

When this figure is reached, or surpassed, efficient operation demands considerable thought as to laboratory design, type of equipment, and general organization. Especially is this true in military aircraft production where numerous castings must be thoroughly examined daily without delay to continuously moving assembly lines. Because the aircraft phase for the moment overshadows other national defense X-ray applications, the present discussion will be confined to this field, although many of the points are applicable on a wider scope.

While space does not permit a detailed description of methods and techniques, some general suggestions are as follows.

Pay more attention than customary to dark room layout and equipment, even when only one X-ray machine is used. Radiographic output is limited by processing facilities, and an undersized developing tank, or insufficient hangers, or a poor technician can bottleneck everything. Moreover, radiographic quality depends nearly as much on dark room practice as on actual X-ray technique—a point seemingly disregarded or overlooked in many industrial plants.

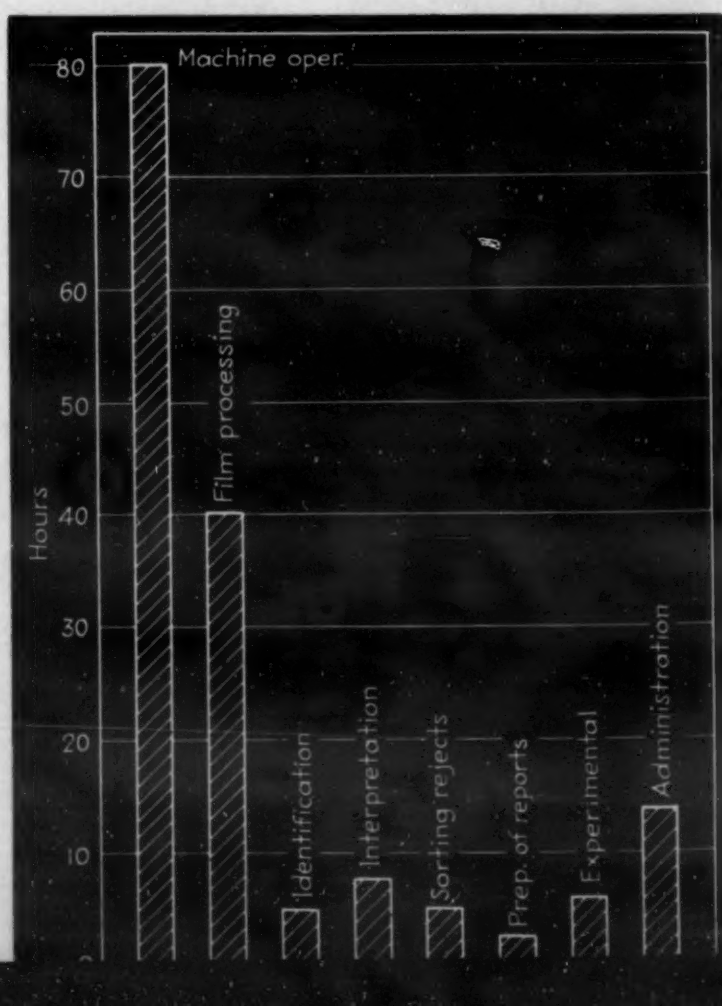
Allot more space than at first appears necessary to the exposure room and provide the best possible illumination. Furnish the room with benches or racks which should hold such accessory apparatus as copper and aluminum filters, diaphragms, plumb bob, level, calipers, rules, wooden blocks, masking materials, and plenty of variously shaped lead sheets. Whether the original intent is so or not, there will necessarily be some experimental work done if full economic benefit is to be derived from the X-ray laboratory.

Above all, provide X-ray equipment with the widest possible range of penetrations—for aircraft work, preferably from 25,000 volts to 220,000 volts. Where only one machine is available and considerable latitude of inspection is desired, the older type air-cooled open X-ray tube is undoubtedly superior to the modern completely enclosed, liquid-cooled tube. In the latter, a certain amount of X-ray filtration is inherent and can be increased, but not decreased. Moreover, the tube is an integral part of the whole unit, it cannot be changed, and thus can only be operated within the limits of its rating. If this rating is 25 to 150 kilovolts, it leaves out the upper region. Or if it operates from 80 to 220 kilovolts, then the lower voltages are omitted and radiography of thin materials is definitely inferior. As a result, the only alternative is the purchase of two machines—high voltage and low voltage.

By modification of the older type, however, almost any filtration or voltage is available, from the energizing of a tube used for crystal diffraction studies up to the radiography of 2 in. of steel, or more.

Good layout and equipment are useless for pro-

Average weekly operation. Number of employees—4; hours per employee—40.



duction radiography without a competent system to route aircraft parts through the laboratory. Reception of parts, arrangement, identification, X-ray exposure, film processing, film interpretation, sorting good from rejected pieces, and report preparation are all activities which should proceed on a schedule. In the accompanying graph, relative importance of these operations at the Bell Aircraft Testing Laboratories is represented in man-hours per week, assuming four men each work a 40-hr. week.

Although any production system should work on a schedule, still there must be enough flexibility to allow for emergencies, such as rush jobs from machine shop and experimental departments as well as from the airplane assembly line itself.

In closing—it is better to have personnel trained in all phases of X-ray work than to have one expert machine operator, one expert film processor, etc. There is a marked improvement in radiographic results when technicians are allowed to change off duties occasionally, and the temporary absence of no one employee is then of particular importance.

Spectrographic Analysis

by Charles C. Nitchie

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Bausch & Lomb Optical Co.,
Rochester, N. Y.

In a period like this, time is the most valuable thing in the world. Maximum production is a vital necessity but, with it, the quality of materials that enter into the construction of aircraft and other defense products must be kept at the highest possible level. Under these conditions any development that helps to speed up production and at the same time insures better control of quality is a matter of the utmost interest.

The success that has attended the use of spectrographic methods of analysis in the laboratories of metallurgical and manufacturing plants throughout the country is a clear indication that just such a development has been accomplished. Iron and steel, aluminum, copper, nickel, magnesium, lead, and zinc—these and the many other metals and alloys, so essential to the program for National Defense, are all being produced under spectrographic control.

Time is saved and production increased because analyses are made so rapidly and with such quantitative accuracy that frequent checks can be made to be sure that operations are proceeding properly and that the metal is of the required composition before it is poured in the molds. Errors in the furnace charge or in processing are detected in time to permit correction. Production of off-grade material and the attendant loss of time for re-working are avoided. Refining is followed so closely that there is no uncertainty in judging when the required end point has been reached.

The speed and extreme sensitiveness of spectrographic analysis are proving equally valuable to the manufacturer who uses the products of the smelter and refinery. Small variations in the composition of alloys, or the presence of traces of impurities often result in marked variations in the physical and other properties. Adequate inspection of the metals to be used, to make sure that they comply with the required specifications, avoids difficulties in manufacture and failure of the fabricated parts in service.

With the spectrograph this inspection is carried out quickly and accurately, checking both the essential alloying elements and also any undesirable impurities that may be present.

This is particularly important to those industries that use secondary metals which may contain impurities that are not ordinarily found in virgin metals of that same kind and that might, therefore, escape detection if analyses were made only by conventional chemical procedures. The photographic spectrum plate that provides the analysis for the normal constituents of an alloy, also reveals the impurities—both those that are to be expected and those that may have crept in from scrap of unusual composition. No special procedures or precautions are needed, other than a careful examination of the recorded spectrum and the identification of any of its lines that do not appear in the spectrum of a standard sample of acceptable quality..

These are but a few outstanding examples of the way in which spectrographic analysis is helping to speed up the production of defense materials. Many others might be cited not only in the metal industries but also in other fields where close control of composition and purity is essential. They are sufficient to justify the conclusion that it deserves serious consideration in every industry in which production and quality are dependent on analytical control.

★ ★ ★

Tensile strengths of rods, plates, welded materials, screws, cams, turnbuckles, cables, etc., as well as the stress in position on power, transmission, guy-strand and other wires can be determined quickly with precision dynamometers.

—W. C. Dillon & Co.

★ ★ ★

The Frankford Arsenal uses a portable Brinell hardness tester for testing ammunition calibrating plates. Two men make the tests in 10 mins. per plate on the shop floor. Formerly, it took 4 men 20 mins., the plates being hauled by truck to the stationary Brinell in the laboratory.

—Andrew King

Editorials *(Continued from page 433)*
1941, the capacity for making electric steel has expanded in 6 months to 3,272,370 tons—an increase of 27 per cent over that of Dec. 31, 1940. And in the past year and a half, this capacity has risen nearly 75 per cent.

Expanding this official analysis a little further we find that since 1920 or in 20½ years, the electric steel industry has increased its capacity 134 per cent—a really remarkable development. Ten years previous to 1920 the industry in this country was in its swaddling clothes.

Devoted as it is largely to the production of high quality alloy steels, this striking expansion emphasizes the constantly greater demand for these steels.—E.F.C.

letter TO THE EDITOR

"Practical Metallography of the Stainless Steels"

We have received from J. H. G. Monypenny, of Brown, Bayley's Steel Works, Ltd., of Sheffield, England, some comments on the article on the above subject by Stanley Watkins in our Jan., Feb., Mar. and April, 1941, issues. Mr. Monypenny is a leading English metallurgist and we are glad to give space to his comments and Mr. Watkins' reply.

Comments by J. H. G. Monypenny

To the Editor: I have been interested in the series of articles by Stanley P. Watkins on the "Practical Metallography of Stainless Steels" which have appeared in the Jan., Feb., Mar. and Apr. issues of METALS AND ALLOYS, and have particularly admired the excellent photomicrographs which have illustrated them. With much of the text of these articles I am in agreement but there are a few matters I should like to raise.

Nickel and Acid Resistance

Fig. 10 (page 35) reproduces a diagram showing the alleged effect of nickel content on the acid resistance of 18 per cent Cr steels; the curve in this diagram relating to the attack of concentrated nitric acid is most extraordinary; it indicates that an addition of 8 per cent Ni reduces the relative rate of attack from 9.0 to about 0.1, *i.e.*, a 90-fold reduction in rate of attack. I should like to know the evidence on which this curve is based as it is quite contrary to my experience. Tests quoted on page 351 of my book "Stainless Iron and Steel" show that the rates of attack of 17.2 per cent stainless iron and of an "18 and 8" steel in boiling nitric acid (density 1.42) were respectively 0.5 and 0.55 grams per sq. met. per hr. and these indicate that 8 per cent Ni has a negligible effect on resistance to nitric acid.

Sigma Phase

The description of the occurrence of the sigma phase on page 165 (Feb.)—"in the straight chromium stainless steels having chromium between 20 and 30 per cent and in the Cr-Ni grades"—is rather misleading. Fe-Cr alloys containing about 40 to 52 per cent Cr consist entirely of this phase when suitably annealed and after similar treatment, alloys containing below 40 per cent down to about 30 per cent consist of the alpha and sigma phases in equilibrium. So far as I know, there is no evidence of the occurrence of the sigma phase in pure Fe-Cr alloys at less than about 30 per cent Cr, though it may—and frequently does—occur at lower chromium levels in complex alloys. As regards—"the chromium-nickel grades," evidence indicates that the sigma phase occurs in steels in this category only when they are not completely austenitic and not always then; it depends on their composition. I recently summarized available information regarding this phase in two articles in *Metallurgia* (Mar. and July, 1940).

Grouping Stainless Steels

It is much easier to group stainless steels according to their metallographical characteristics than to give composition limits for each group. The limits given on page 166 for martensitic and ferritic alloys are not very helpful, however. The range of composition given for martensitic alloys (0.05 to 1.10% C and 11 to 18% Cr) includes many compositions which are practically unhardenable, whereas the range for ferritic alloys—0.05 to 0.35 per cent C and 14 to 30 per cent Cr—includes some (*e.g.* 0.035% C with 14% Cr) which are very definitely hardenable. The values given are not likely, of course, to cause trouble with people who have practical knowledge of the steels, but they may perhaps lead to confusion in the minds of those whose acquaintance with the steels is slight.

The accuracy of the statement on page 432—"on the other hand, if the alloy is heated for *several hours* within the sensitizing range, it will become more stable and less susceptible to intergranular attack"—depends on the interpretation put on "several." Bain, Aborn and Rutherford showed, for example, that intergranular susceptibility in an "18 and 8" containing 0.08 per cent C increased continuously with time when heated at 650 deg. C. for periods up to about 90 hrs., and with higher carbon contents, the period should be still longer.

On page 432 the well known acid copper sulphate reagent for detecting intergranular susceptibility is referred to as the "Strauss reagent." It has been pointed out on several occasions that this description is inaccurate; the use of this reagent originated in the Brown Firth Research Laboratory, Sheffield, under the direction of Dr. Hatfield.

Stabilizing with Ti and Cb

On page 434 the author states—"it is considered necessary to give the 18 and 8 titanium material a stabilizing treatment in order to obtain full effect of titanium, but in the case of columbium, this is not so." The present writer

nas no wish at this moment to enter into a controversy as to the relative merits of titanium and columbium except perhaps to point out that considerably more of the latter is required than of the former to produce like effects.

The question of the necessity or even the advisability of giving a stabilizing treatment to sheets, plates, or other forms of either of these steels, which have subsequently to be welded is, however, a matter about which there seems to be some confusion of thought. Stabilizing at 880 deg. C. or thereabouts ensures preferential precipitation of titanium or columbium carbide, as the case may be, and no one denies that material of either steel so treated is likely to develop susceptibility on subsequent heating at 650 deg. C. or thereabouts than similar material which has been softened at 1100 deg. C. or so and not subsequently stabilized.

But what is the use of stabilizing before welding? The welded joints are much more in need of stabilizing than the normally softened sheet or plate; this applies particularly of course to the actual weld metal which has lost some at least of the stabilizing addition whether it be titanium or columbium, but it also applies to the adjoining parent metal which, though not melted, has been heated to temperatures approaching the melting point at which much, if not all, of the pre-existing titanium or columbium carbide will have been taken into solution. If a stabilizing treatment is really desirable it should be done after welding is completed in order that the welds—the parts most in need of such treatment—may benefit thereby. At the same time it is fair to state that many tons of titanium-treated "18 and 8" steels have been successfully used in this country—and probably also in U.S.A.!—without any stabilizing treatment at all.

Martensite and Ferrite

There is one further small matter (in the Mar. number) which I might perhaps mention: Fig. 40 shows a laminated structure of martensite and ferrite, which is stated to have been formed in material containing 18 per cent Cr and 0.1 per cent C. The amount of martensite in this photograph is very large for material of this composition (unless it contains some other hardening element, *e.g.* nickel) and contrasts rather remarkably with the other photographs of this material which are given in Fig. 34E, Fig. 35 Zone III, Fig. 37 and Fig. 41. The last named has, of course, been tempered, the martensite being, therefore, partly decomposed, but the area occupied by these decomposition products would of course be the same as that of the original martensite. There seems little doubt that Fig. 40 can hardly be considered typical of straight 18 per cent Cr iron, containing only 0.1 per cent C after quenching or air cooling from any temperature.

J. H. G. MONYPENNY

Brown, Bayley's Steel Works, Ltd.
Sheffield, England

The Author's Reply

To the Editor: The comments Mr. Monypenny makes regarding my recent article on the "Practical Metallography of the Stainless Steels" are well taken and most helpful in pointing out certain parts which are contrary to his own experience. Mr. Monypenny's book "Stainless Iron and Steel" is a classic in the field and has long been a standard reference book in this country, and Mr. Monypenny himself is considered one of the foremost authorities on stainless steel by the metallurgists in America.

The diagram shown by Fig. 10 was based on data published by E. C. Rollason of the University of Birmingham (England). These data appeared in Part I of his paper entitled "Stainless Steels" which was published in the November 1935 issue of *The Welder*, an English trade paper published in London.

Nickel and Acid Resistance

Our experience in regard to the effect of nickel additions on the resistance of 18 per cent Cr material to boiling nitric acid is contrary to that reported by Mr. Monypenny. He states that the addition of 8 per cent Ni to an 18 per cent Cr alloy has a negligible effect on its resistance to boiling nitric acid. The data shown below, which are typical rates for material produced in this country, definitely indicates that nickel to the amount of 8 per cent improves resistance to boiling nitric acid:

Grade	C	Cr	Ni	Heat Treatment	65% Boiling HNO_3 2—48-Hr. Periods—In./Pen./Mo. 1st	2nd
17% Cr	0.06	17.13	...	1450°F.—WQ	0.00217	0.00307
17% Cr	0.12	17.41	...	1450°F.—WQ	0.00212	0.00239
17% Cr	0.15	17.21	...	1450°F.—WQ	0.00226	0.00237
18-8	0.09	18.16	8.03	1950°F.—WQ	0.00077	0.00080
19-8	0.05	19.30	8.32	1950°F.—WQ	0.00089	0.00066
19-8	0.07	19.51	8.06	1950°F.—WQ	0.00078	0.00074
18-8	0.06	18.50	7.90	1950°F.—WQ	0.00087	0.00085

The Sigma Phase

In a letter to the Editor of *Metal Progress* and published in the January 1940 issue of that magazine, H. Hougardy of Germany indicated that sigma phase could exist in the binary Cr-Fe system and may be found in alloys ranging from 20% Cr to 80% Fe to about 60% Cr and 20% Fe. Kinzel and Franks in their book, "Alloys of Iron and Chromium," Vol. II, recognize the existence of a "brittle" constituent in Cr-Fe alloys containing more than about 20% Cr, but do not agree that it is sigma phase. They prefer to term the phenomenon as "475 deg. C. brittleness." Nevertheless, it is a well recognized fact that the straight chromium stainless steels containing above about 20 per cent Cr develop brittleness as evidenced by reduced elongation when slow cooled from the range of 1500 to 1700 deg. F. as shown by the following data:

C	Cr	Heat Treatment	Ult. Ten. Str., lb. per sq. in.	Red. of A., per cent	Elongation, per cent	Brinell Hardness
0.21	26.61	1500°F.—3 Hrs.—WQ	76,500	51.0	30.0	160
		1600°F.—3 Hrs.—WQ	75,000	22.0	10.0	160
		1700°F.—3 Hrs.—WQ	74,000	22.0	8.0	160
0.21	26.61	1500°F.—3 Hrs.—FC	80,000	0.4	1.0	217
		1600°F.—3 Hrs.—FC	70,500	0.4	1.0	197
		1700°F.—3 Hrs.—FC	69,000	0.4	0.5	197

Mr. Monypenny is correct in calling attention to the fact that sigma phase does not generally occur in the Cr-Ni stainless steels if they are completely austenitic. It is generally agreed that sigma phase corresponds to the compound FeCr and occurs when free alpha or delta iron reacts to form this compound plus gamma iron.

Grouping Stainless Steels

In regard to the classification of the stainless steels as given in my paper, Mr. Monypenny's contention that such a grouping is apt to confuse one having a slight knowledge of these materials is doubtless true. On the other hand, the alternate grouping suggested by Mr. Monypenny is open to the same criticism inasmuch as the terms "Ferritic," "Martensitic" and "Austenitic" are unlikely to be clearly understood by the uninitiated. Perhaps a grouping as follows would assist those not well versed in the stainless steels to differentiate between the alloys of Groups

I and II. However, the line cannot be finely drawn between these groups, as certain alloys in Group I may contain a small amount of free ferrite on hardening and on the other hand, alloys in Group II will develop martensitic areas when quenched from high temperatures.

Group I—Straight Chromium Stainless Steels:
Martensitic (Hardenable).
Analysis range: Carbon 0.05 to 0.40 per cent with chromium 11 to 14 per cent. Carbon 0.60 to 1.10 with chromium 16 to 18 per cent. Plus small supplementary additions of molybdenum, sulphur and nickel.

Group II—Straight Chromium Stainless Steels:
Ferritic (Practically Non-Hardenable).
Analysis range: 0.05 to 0.15 per cent carbon with 16 to 18 per cent Cr. 0.05 to 0.35 per cent C with 20 to 30 per cent Cr. Plus small supplementary additions of molybdenum and sulphur.

Group III—Chromium-Nickel Stainless Steels:
Austenitic (Hardenable by cold work only).
Analysis range: Carbon 0.05 to 0.20 per cent with chromium 17 to 29 per cent and nickel 7 to 14 per cent. Plus small supplementary additions of molybdenum, titanium, columbium, tungsten, sulphur and selenium.

Mr. Monypenny has indicated that to be true, a liberal interpretation is necessary of my statement "on the other hand, if the alloy (18 and 8) is heated for *several hours* within the sensitizing zone, it will become more stable and less susceptible to intergranular attack." The data presented below show the effect of heating an 0.05% C, 19% Cr, 8% Ni alloy at 1450 deg. F. for 6 hrs., and subsequently heating at various temperatures within the sensitizing range and then exposing the specimens to 65% boiling nitric acid. The short period at 6 hrs. definitely effects considerable "stabilizing" and this period, to the writer's belief, would ordinarily be regarded as "several hours":

Deg. F. Treatment	65% Boiling Nitric Acid Aver. 2—48-hr. Periods—In./Pen./Mo.
1950-WQ+1000°F.-24 hrs.-AC	0.0130
1950-WQ+1100°F.-24 hrs.-AC	0.0230
1950-WQ+1200°F.-24 hrs.-AC	0.0030
1950-WQ+1300°F.-24 hrs.-AC	0.0015
1950-WQ+1400°F.-24 hrs.-AC	0.00100
1950-WQ+1450°F.-6 hrs.-AC+1000°F.-24 hrs.-AC	0.0060
1950-WQ+1450°F.-6 hrs.-AC+1100°F.-24 hrs.-AC	0.0040
1950-WQ+1450°F.-6 hrs.-AC+1200°F.-24 hrs.-AC	0.0022
1950-WQ+1450°F.-6 hrs.-AC+1300°F.-24 hrs.-AC	0.0010
1950-WQ+1450°F.-6 hrs.-AC+1400°F.-24 hrs.-AC	0.00075

Tests made in an attempt to correlate rate of nitric acid attack and intergranular attack by "Strauss Reagent" have shown that if the rate of attack by a boiling 65% solution of nitric acid exceeds about 0.005 in./pen./mo. in the second 48-hr. period, the 18 and 8 material will become embrittled by the "Strauss Reagent."

The term "Strauss Test" or "Strauss Reagent" is widely used in this country for designating the sulphuric acid-copper sulphate solution used in determining the susceptibility of the 18 and 8 stainless steels to intergranular attack. We are indebted to Mr. Monypenny for calling our attention to the fact that this reagent was developed by Dr. Hatfield and not by Mr. Strauss as the term "Strauss Test" implies.

Stability with Ti and Cb

Mr. Monypenny has questioned the statement regarding the necessity for stabilizing 18 and 8 titanium material in order for it to develop full resistance to sensitization whereas this treatment was not considered necessary in the case of the 18 and 8 columbium alloy. In a paper written by Russell Franks, entitled "Effects of Special Alloy Additions to Stainless Steels," he states with respect to titanium "when titanium is used it must be present to the extent of at least six times the carbon content, and the steel must be given a stabilizing heat treatment within the range 850 to 900 deg. C. (1550 to 1650° F.) for a period of from 2 to 4 hrs., followed by air cooling." In regard to 18 and 8 columbium, the same author states "when complete immunity to intergranular attack is required between 300 to 800 deg. C. (570 to 1470° F.), the columbium content should be equivalent to at least 10 times the carbon content. The same results can be obtained if the 18 and 8 steel contains at least 8 times as much columbium as carbon and is given a stabilizing heat treatment after annealing, which consists of holding for 2 hrs. at 850 to 900° C. and air cooling."

It has been shown by work conducted in this country that the solubility of columbium carbides at about 2000 deg. F. is much lower than that of titanium carbides. In other words, insofar as carbide precipitation is concerned, the need for a stabilizing heat treatment after annealing at about 2000 deg. F. is much less with columbium than with other stabilizing elements.

Since columbium carbides in 18 and 8 go into solution very slowly at a temperature of about 2000 deg. F., tests have indicated no advantage in giving this material a stabilizing treatment after annealing provided the ratio of columbium to carbon is better than 10:1. With a ratio lower than this, a stabilizing treatment is required if the material is to operate in service at a temperature in excess of 900 deg. F. in a corroding medium. On the other hand, 18 and 8 titanium material requires a stabilizing treatment after annealing at about 2000 deg. F. owing to the fact that titanium carbides are largely dissolved at this temperature. Preferential precipitation of the titanium carbides is accomplished by heating in the range of 1550 to 1650 deg. F. It is the general practice among producers in this country to give all 18 and 8 titanium material a stabilizing treatment before shipping to fabricators. In addition, it is generally recommended that this material be given an additional stabilizing treatment after fabrication by welding, but some users consider this a superfluous operation. It is a universal practice in America to use 18 and 8 columbium weld rods for welding both 18 and 8 Cb and 18 and 8 Ti material.

Mr. Monypenny's contention that it would be more logical to give 18 and 8 Cb and 18 and 8 Ti material a stabilizing treatment *after* instead of *before* welding is logical, but laboratory tests, as well as field service, have shown that in the case of the 18 and 8 Cb alloy, a stabilizing treatment after welding is unnecessary. Also, it is doubtful if any real benefit results from giving the 18 and 8 Ti alloy a stabilizing treatment after welding, provided the material is in the stabilized condition before fabrication and 18 and 8 Cb weld rods are used in welding.

Martensite and Ferrite

Mr. Monypenny is quite right in calling attention to the relatively large amount of martensite shown by Fig. 40 which contrasts with Figs. 34E, 35 Zone III, 37 and 41. All these photomicrographs are of commercial material and the nickel varies between 0.15 and 0.50 per cent, which explains in part the varying amounts of martensite revealed by the different specimens. Also, nitrogen is effective in increasing the amount of martensite retained when the 17 per cent Cr grade of stainless steel is rapidly cooled from above its critical point. Nitrogen content in this alloy will range between 0.03 and 0.08 per cent.

STANLEY P. WATKINS

METALLURGICAL ENGINEERING news

Equipment
Finishes
Materials
Methods
Processes
Products

Alloys
Applications
Designs
People
Plants
Societies

Defense Perspectives

Beginning with this issue and continuing for the duration, METALS AND ALLOYS *will publish this column devoted to defense activities as they relate to the metallurgical engineering field. The column will be not merely a listing of news items, but a review and interpretation for the metallurgical engineer of the mass of general defense news issued each month.—The Editors.*

Scrap Crisis

Last month the OPM called on the scrap dealers to aid national defense when an all-out program was launched to have the scrap brokers collect 20% more scrap. To start the program off right, about 80 top scrap men were called to Washington to plan the campaign.

Right now a shortage of metal scrap looms as a major obstacle to maximum capacity production in the metal industries. This fact is emphasized by the report that about 25% of all steel produced this year will come from reclaimed steel scrap; copper scrap will make up 34% of the copper supply; 22% of the aluminum production and 20% of the lead production will be reclaimed from scrap.

From all reports, it seems that the collection of scrap is not as much a problem as is the task of moving it towards defense production once it is accumulated. Beginning back in June, scrap collection drives were started all over the country. Late August and September saw increased activities for obtaining additional scrap iron and steel through auto scrap drives. But the indecisive steps taken in setting up scrap priorities and price ceilings slowed up, almost to a standstill, the distribution process.

The aluminum drive was the prime example of this. After the 14,000,000 lbs. of pots, pans, bicycles and baby carriages was collected, complications arose to slow up the moving process. Mayor La Guardia planned to sell direct to the smelters at 11.5c a lb. The smelters were agreeable until they discovered that only a fraction of the stuff they bought was aluminum.

The falling price of aluminum retarded matters also. The scrap dealers held off for fear that similar reductions would be made on the price of secondary aluminum and that they would be squeezed between the buying and selling price.

Small Business and Defense

On Sept. 4, President Roosevelt created within the OPM the Div. of Contract Distribution in a determined effort to save small business units by putting them to work on defense.

Up until this time small business was pigeon-holed in preference to established defense production and the more easily accessible big business. While huge defense orders were way behind schedule because big business, in many cases, lacked some of the essentials, hundreds of small plants such as tool shops, machine shops, and die casters, all over the country were idling down, scarcely moving, for lack of work. And yet they could have supplied many of the things that big business needed or were too busy to make themselves.

With the creation of the Div. of Contract Distribution, the first definite step was taken toward studying the situation and setting up means of using the varied talents of small business. This will be accomplished in 4 major steps: (1) By breaking down larger orders into smaller units and spreading the work among small firms; (2) providing assistance in relocating labor, where reduction of work has caused unemployment; (3) by expanding the use of subcontracting for the benefit of smaller business enterprises; (4) by providing a staff of industrial and production engineers to formulate and execute the plans.

Already the machinery of the new service is functioning. Meetings, conferences and clinics are being held to discuss the problems and point the way to their solution. In New York City a large clinic was held. Prime contractors were present with detailed specifications of what work they could sub-contract. In Chicago, a campaign was launched on behalf of the small manufacturers. Programs have been formulated for the conversion of plants and industries from civilian to defense production. It is hoped that the help will not come too late.

Conservation

A nation-wide conservation program was inaugurated last month when the Conservation Bureau of OPM requested bicycle manufacturers to conserve material and man-power by simplification of design, substitution of materials and a reduction of the number of models. This was the first direct action by OPM to effect savings throughout industry. During World War I, bicycle models were reduced to 3, and it was estimated that this made possible a substantial saving of steel.

The American fire engine is destined to lose some of its glamour. Leading manufacturers met recently with the OPM and decided to reduce their use of critical metals. The brass, aluminum, copper and similar metals which helped make the engine beautiful are going to be eliminated. The metals will be more valuable elsewhere. (But what will Fiorello say?)

The first of the 1942 automobiles showed little evidence of metal shortages, at least on the surface. Stainless steel has replaced chromium-plate in some cases. Nickel still glitters in the trimmings. Some auto manufacturers have retained their aluminum pistons and cylinders while others have substituted cast iron. Plastics have largely re-

(MORE NEWS ON P. 518)

Variations in Composition Among Refractory Mixtures

The vast array of refractory mixtures available for different applications under a great variety of conditions might indeed be confusing to a user of refractories. This is true because almost every refractory mixture or combination of materials is designed having in mind definite ceramic, chemical, physical and physical-chemical factors that are necessarily involved.

Actually, the basic or fundamental refractory materials available to industry are relatively few, but the possible desirable combinations of these few are very great. These fundamental materials are usually

Good characteristics in refractory materials start at the electric furnace plant with careful analysis of the raw materials

divided into three chemical classifications, i.e., (a) Acid (silicon carbide and silicious material (b) Neutral (chromite, alumina) and (c) Basic (magnesia). Naturally, materials in each classification show definite physical and chemical characteristics. Whatever may be their classification, combinations of two or more materials, with proper heat treatment, provide the refractories required by industry in this day of heavy production demand.

(a) *Types of Refractories*

The user of a furnace or other high heat installation might procure refractories of one or more kinds, as for example, (a) Preformed shapes, either fired or unfired; (b) Dry mechanical mixtures; (c) Semi-dry mixtures; (d) Wet mixtures; (e) Slip mixtures (for pouring) or as (f) fused cast refractories.

Three electric furnace refractory materials—silicon carbide (Crystolon), fused alumina (Alundum) and white fused alumina (38 Alundum)—each with different characteristics

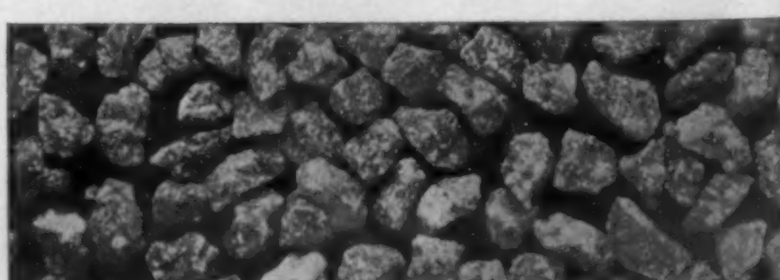
Those mixtures b, c, d and e might vary from each other only in percentage of H_2O content or they might have added difference like grain size and shape or in the type and percentage of bond.

(b) *Bonding Ingredients*

Bonding characteristics in any refractory mixture are extremely important. In fact, a poor selection of bond may render useless the highest quality of basic refractory. In such cases, the bond proves to be the weak link.

The following kinds of bonds are in satisfactory use depending upon the conditions involved.

1. Slip Clays
2. Ball Clays
3. Plastic Fireclays
4. Hydraulic Cement
5. Sodium Silicate
6. Phosphates
7. Oxy-chlorides



How 36 mesh Alundum refractory grains look when magnified 12 diameters—uniformity in both size and shape is evident

Different types of clay bonds are used to meet different operating conditions

(c) *Burning Conditions*

The behavior of preformed refractories when being initially kiln fired depends upon three principal factors, i.e., (a) the composition; (b) the firing temperature and (c) the atmosphere in the kiln.

Having determined the best composition, both physical and chemical, of the refractory mixture to be used, the next control to be instituted is that of kiln firing which involves the rate of heating and cooling; the control of atmosphere to the point where it is definitely oxidizing, or reducing or neutral according to the chemical nature of the material being fired; and finally the best temperature to mature the body properly.

The human element in grit sizing is eliminated by the use of thoroughly tested screens and machines which guarantee practically perfect seiving accuracy

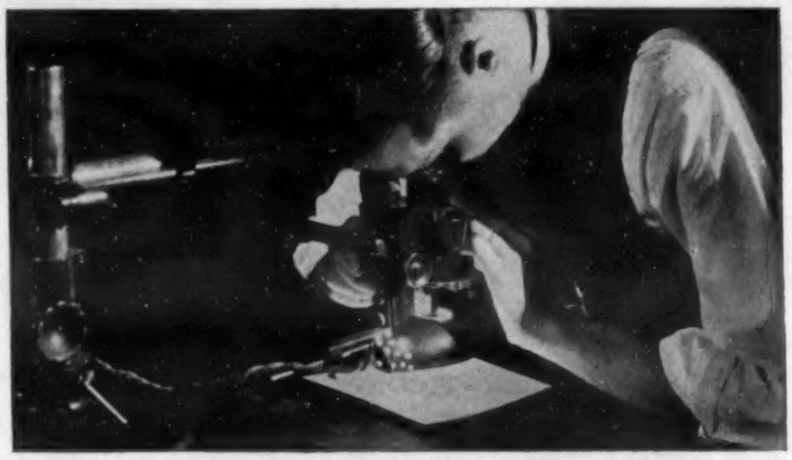
All these controls are necessary because variations in one or more of these factors can produce variable results in the finished product.

(d) *General Applications*

All these combinations of materials and various production controls are necessary because there is no refractory which is perfect for universal application.

In other words it is frequently necessary to make a "compromise" product. First, the conditions to be met must be carefully analyzed and set down in the order of their importance. When this is done, selection of the most suitable refractory, for best fulfillment of most of the demands, may necessitate the relaxing of desirable characteristics in some other direction.

Such relaxing must of course be confined to the characteristics least important for the particular application.



Refractory grains have different shapes which are brought out under the microscope by means of special lighting

(e) *Metallurgical Effects*

In metallurgical operations it is many times desirable to have a reducing atmosphere because of the possible oxidation of metals at high temperatures. So the metallurgist must take into account the possibility of contamination of his charge in contact with the refractory being used. Under reducing conditions at high temperatures, silica is liable to be reduced to silicon and this would tend to add silicon to the molten charge when such addition is definitely undesirable.

Under other conditions, carbon may be added to the molten charge. In fact, a variety of impurities may contaminate the molten material unless the selection of the refractory is very carefully made.

placed zinc, chromium-plate and steel on the inside trimmings.

The big conservation of metals and alloys will come from the 32.2% curtailment of auto production from Aug. through Dec. this year. [*For engineering data on substitutions in the automotive industries, see the digest "Metal Supplies and Substitutes" on p. 620 of this issue.*]

The A. S. T. M. is undertaking a series of investigations looking for a possible reduction in aluminum content from about 4% to about 1.5-2.0% in zinc-base alloy die castings. Investigations of this sort are essential to savings in virgin metals. Real conservation is more than a substitution process or the discontinued use of scarce materials in non-essential industries. Some of the greatest savings can be effected by wise and efficient alloying methods.

Steel

The year-old controversy over the adequacy of the nation's steel-making facilities appeared to be settled when the OPM decided to increase the steel making capacity of this country 10,000,000 tons a year. But most of the steel companies have requested, not new self-contained steel plants but improvements of existing facilities so that they will be able to operate at full capacity next year.

Besides this snag, it is a commonly held opinion that a "10-million ton" steel expansion could not possibly produce 10 million more tons of steel a year for some time because the extra raw material required (including over 4 million tons of steel itself) to feed such an expansion cannot be supplied for two years.

Although the OPM on July 23rd announced the proposal to increase pig-iron production capacity by 6.5 million net tons a year, by now contracts for only 1/3 of the program have been executed. Sixteen Great Lakes ore carriers will be necessary to move the additional iron ore required. These will be finished at the earliest by 1943.

So the problem of steel capacity expansion is still unsolved.

Bending Presses

The Steelweld Machinery Div. of Cleveland Crane & Engineering Co., Wickliffe, Ohio, announced recently that their bending presses were furnished with a ram-tapering mechanism that makes possible a new field of applications.

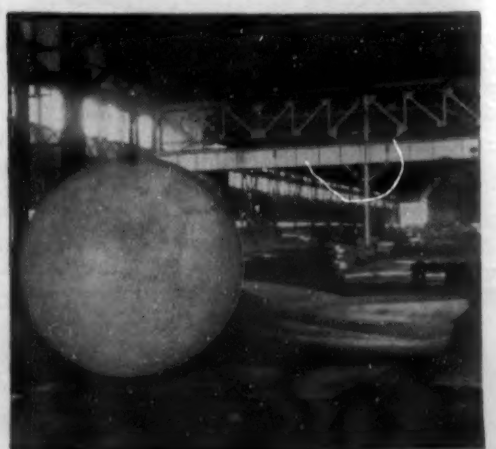
The tapering mechanism enables making conical sections without the use of special dies. The work can now be done with standard bending dies.

Tapering the ram is extremely simple. It is only necessary to operate the ram-tapering lever, which disengages the ram clutch. This permits operation of the right-hand ram screw only, which raises or lowers the right end of the ram, thus producing tapering. Either end of the ram can be tapered as much as ¼ in. per ft. length of bed.

There are no bolts to loosen or tighten. The ram swivels on trunions in the slides so there is no cramping on guides or bearings.

Stainless-Clad Steel

By substituting stainless-clad steel for solid stainless, savings were made of 35% in material costs and 80% in the amount of chromium and nickel required in the flanged and dished heads shown in the accompanying photograph, it was pointed out by *Jessop Steel Co.,* Washington, Pa.



These 108 in. diam., A. S. M. E. code heads were fabricated by hot spinning in the plant of *Lukens Steel Co.,* at Coatesville, Pa. The savings in chromium and nickel are particularly significant in view of the fact that these strategic materials are now on the priority list.

(MORE NEWS ON P. 520)

Welding Equipment

The welding equipment manufacturers are designing at the present time with the thought of faster production most prominently in mind. During the past month, two companies have added to their line of resistance and arc welders as well as to their auxiliary welding equipment.

High-Speed Welding

For speeding-up production, the *Progressive Welder Co.,* Detroit, recently brought out two new resistance welders, one for the ammunition industry and another for the automotive field.

Cases for transporting loaded 25-lb. shell, ready for firing, are now being assembly-welded in at least one plant at a rate of 180 complete cases per hr. With 24 welds per case, 4,320 welds are made per hr. Assembly specifications call for unusually close tolerances for this type of work, to hold the shell securely and permit stacking of cases for transportation.

The welding machine, designed for this operation, is equipped with a power-clamping fixture to facilitate loading and unloading. The parts for the case are dropped over and into the locating fixture, which also forms one of the electrodes.

A lever is pulled down and plates come against the work under power, clamping the parts securely in the fixture and against the inner electrodes. The 24 welding gun units then move in against the work, and the welding cycle starts. On completion of the welds, the points move away from the work, the clamps are retracted by reversing the lever, and the assembled case is removed.

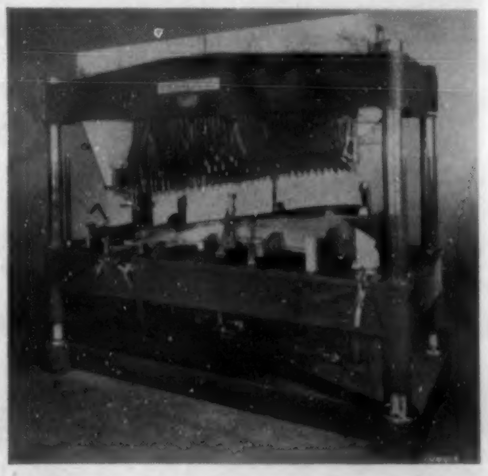
Operation is completely automatic from the moment the clamping action is started, until the case is ready for removal.

The job of spot welding a wheel housing to the rear quarter panel of an automotive body is being done by the welding unit shown in the accompanying photograph. Thirty-six hundred welds an hr. can be made. The complete cycle of the unit requires only 40 sec., including the time for loading and unloading the fixture, bringing the points down against the work, and going through the welding cycle, 2 welds at a time.

Besides these 2 stationary units, the same company has announced a line of portable welding machines with built-in transformers designed for suspension from monorails, etc. They have particular advantages in such applications as:

1. Spot welding of large units requiring clearance from the ground under the welding arms, or of heavy units.
2. Spot welding of parts on a conveyor.
3. Spot welding assemblies in several jigs in one department, requiring movement of the welding equipment.
4. Pinch welding of spots not easily accessible with gun type welders due to throat limitations.
5. Jobs which can be handled most effectively by a unit suspended from a swinging or traveling crane.

In effect, the new welding machines are a cross between "pedestal" and gun welders.



Like welding guns, they may be moved or swung around to bring the gun to the work, reducing work handling. Like pedestal welders, they have rigid arms with a high degree of throat depth, and the higher degree of efficiency going with the eliminating of secondary cables.

Aircraft Arc Welder

Hobart Brothers Co., Troy, Ohio, has introduced a specially designed arc welder for aircraft construction purposes. Although it embodies the same design and operating speed (only 1750 r.p.m.) as other Hobart multi-range arc welders, it has been modified to give the "quick, hot start" necessary to success in welding light gage alloy tubular members in airplane construction. It also provides a lower range of welding current specified from 10 to 150 amps. at normal welding voltage.

Characteristics of this machine adapt it to the welding of light gage metals that are weldable by the electric arc—especially the welding of X-4130 chromium-molybdenum steel on aircraft engine mounts. This type of welder has also been used in a large ship yard where stainless steel trimming bands 0.030 in. in thickness were welded during installation of several ships' galley equipment.

The machine welds especialy well with coated electrodes of 1/32-in. to 5/32-in. size, without burning through, and with steady progress along the seam due to the "soft arc" that "hangs on" even under low current conditions.

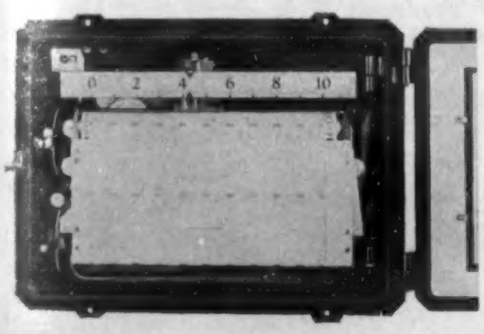
Welding Machine Trailer

A new four-wheeled, light-weight, pneumatic-tired trailer for mounting all Hobart electric drive welders is announced by *Hobart Brothers Co.*, Troy, Ohio. Portability makes this new welder useful for hurry-up trips to different parts of the plant and yard for emergency production, maintenance and repair work.

The trailer is designed so that the mounting is easily accomplished by means of 4 bolts in the frame of the trailer, which register with 4 holes in the legs of the welding machine. Unit is easily moved by hand by virtue of the low, underslung construction, narrow 27-in. tread and method of balancing. Trailer is of arc-welded steel construction throughout.

Temperature Controller

A new proportional controller for applications in which throttling control with or without automatic reset is required has been announced by *C. J. Tagliabue Mfg. Co.*, Brooklyn, N. Y.



The manufacturer reports that the new system of control employs only a control instrument and a valve mechanism, eliminating the relay detector element formerly required.

The method for throttling control accomplished by this instrument may be briefly described as follows: When the temperature is far below the control point, as in starting up, the valve will be wide open; as the temperature rises and enters the throttling zone, the valve will close a relay. This action prevents overshooting as the temperature approaches a balance between heat input and heat loss.

The throttling zone can be readily adjusted within wide limits according to the lag characteristics of the application, and the maximum permissible sensitivity, easily determined in order that the load error be kept within a few degrees on those models without reset.

Processing Shell Casings

Hanson-Van Winkle-Munning Co., Matawan, N. J., has developed a new type of equipment for washing, pickling and rinsing 20-mm. shell casings after annealing.

The pickling unit consists of a double station hot sulphuric pickling tank, a spray rinse compartment, a cold rinse compartment and a final hot rinse compartment. The pickling compartment is lead-lined with lead coils to withstand the hot sulphuric acid used. The warm rinse and the spray rinse compartments are also lead-lined, a lead coil being included for the warm rinse tank for heating purposes.

The unloading hopper on the warm rinse tank is made of Monel metal with ½-in. perforations and suitable exhaust hoods are included for the hot sulphuric acid pickling compartment.

Monel cylinders, 16 in. in diam. x 30 in. long with ½ in. perforations, gears and hangers made of bronze, ¼ in. Monel heads and ⅛ in. body stock are included. Cylinders of this size hold about 600-700 shells.

It is noteworthy that shell casings must be drawn, annealed and pickled at least 6 times.

Plastics

Plastics are receiving more and more attention as the defense program gains impetus. Here are a couple of places where plastics are being substituted for scarce and strategic metals.

Plastic Fans

The longest mold ever made by the plastics department of the *General Electric Co.* is being used at West Lynn, Mass., to produce fan blades formerly made of metals. The fan blades, 4½ ft. long, weigh approximately 25 lbs. each and are used for cooling tower fans. Four blades are assembled on a moly cast iron hub to make a fan 12 ft. in diameter.

A molded plastic fan blade is particularly important at this time because of the need of metals formerly used, such as aluminum and magnesium, for defense.

The new plastic blade is lighter than the metal blades it replaces, but is of about equal strength.

Corrosion was the chief trouble in the use of metal blades. This problem was particularly acute in many localities where contact with even a small amount of salt water caused corrosion. To offset this, the metal blades had to be painted and baked. The plastic fan eliminates this difficulty.

Another advantage, which is expected to result in an increase in efficiency, is that the plastic blades have the theoretically exact surface which is smooth, due to the fact that they are made from a mold.

Plastic Hammer Heads

Hammers with heads of cellulose nitrate plastic now are used extensively by pewtersmiths, silversmiths, tinsmiths, mechanics, craftsmen, woodworkers, machinists and metal workers of all types, according to *E. I. du Pont de Nemours & Co., Inc.*, Wilmington, Del.

These hammers outwore and outlasted wooden, rubber, fiber and other types of soft mallets in a series of tests by manufacturers. Plastic heads, these tests showed, do not chip or break and do not mark silver, gold, pewter, brass, copper, aluminum or similar metals.

Transparent and clean, plastic heads are said not to absorb water, oil or grease and not to deteriorate with age. A pin runs through the head to hold it securely to a wooden handle, thereby minimizing the danger of the head flying off the handle from the force of the blow.

Metals and Plastics Lectures

In order to assist industrial designers, engineers, architects, manufacturers and contractors in meeting some of the problems created by the national defense program, *New York University* has scheduled a series of 15 weekly lectures on modern metals and plastics which began September 23rd.

In these lectures, experts will discuss ways in which the more available materials may be substituted for others, which have become more difficult to obtain.

The speakers will include W. L. Merrill and R. V. Boyer of General Electric Co.; Milton Male of U. S. Steel Corp.; F. L. LaQue and J. W. Sands of International Nickel Co.; N. E. Woldman of Bendix Aviation Corp.; and C. T. O'Connor of Durez Plastics & Chemicals, Inc. Professor Albert C. Schweizer of New York Univ. will act as coordinator of the course.

● Substitution of non-essential composition metal for aluminum foil has been announced by *Reynolds Metals Co.*, Richmond, Va. The new composition metal is used largely for packaging food products.

FREE SERVICE DEPARTMENT

Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd. St., New York.*

HELP WANTED:—Salesmen: New special alloys. High-class repeat business with defense industries. Territories open—N. Y., N. J., Conn., Phila., N. Indiana, Calif., W. Va., Seattle. Attractive commission. Introduced hard workers with technical background (give details). Box MA-27.

HELP WANTED:—Young chemical or metallurgical engineer for technical sales development work. Midwest location. Experience preferred but not essential. Box MA-28.

Automatic Temperature Indicator

Where a large number of thermocouple temperature readings are to be taken, *Leeds & Northrup Co.,* Philadelphia, recommends the use of an automatic indicator, which does the job in minimum time and requires less skill on the part of the operator.

As many as 50 couples can be used with one instrument. All are individually connected to toggle-switches on the indicator front. To read a couple's temperature, the operator throws the switch and a pointer moves automatically to the correct scale position.

There are no dials to turn or galvanometer to watch—the instrument automatically performs these operations, leaving the operator free to make notations.

Metal Marking Tool

A new tool, which can be used handily for engraving, cutting, hammering, or carving on meal, has been announced by *Burgess Handicraft Supplies,* Chicago. The tool makes 7,200 strokes per min., with stroke adjustable up to 1/8 in.

The chuck is designed to grip a large variety of engraving needles, cutting knives, gauges and hammers. Special fittings, such as depth gauges, etc., make it usable for both craft work and production.

The tool can be used to engrave an identification on machines or parts; tools can be permanently marked; and rapid engraving of instrument panels and dials can be accomplished.

Bonderizing Large Metal Products

Facilities to bonderize large metal enclosures for switchgear and electrical control have recently been put into service at the East Pittsburgh works of *Westinghouse Elec. & Mfg. Co.* Result is a reduction in handling of these units and a large saving in time required for the bonderizing process.

Formerly, the enclosures had to be bonderized in sections and then welded together. The welding operation destroyed the bonderized surface, making a very unsatisfactory paint base. Reversing the sequence has eliminated this undesirable feature and has also saved much time and handling in the manufacture of these units.

The photograph shows a completely welded enclosure being lowered into the first of 5 tanks used in the bonderizing process. Here the unit is washed in hot alkaline solution before being rinsed in hot water.

Test for Cracks in Crankshafts

Power presses, recognized as one of the most hazardous groups of industrial machines, are given careful periodic tests at the *General Electric Co.'s* Schenectady works. A valuable test is the magnetic test to which punch-press crankshafts are subjected.

The magnetic test consists of magnetizing the shaft, making the direction of the flux longitudinal so that it will intercept any possible cracks at right angles. While magnetized, the shaft is sprayed with kerosene, which has in suspension finely divided particles of magnetic iron oxide. Any cracks or discontinuities in the metal will set up magnetic poles, which, while very slight, are strong enough to attract and hold the ironoxide particles, thereby outlining a crack that may ordinarily be invisible to the naked eye.

This test is made each time a shaft is removed from a punch-press for any reason, as a punch-press crankshaft is subjected to tremendous strain in operation. One large company recently tested a group of 43 crankshafts, using this method, and found that 14 of them were cracked and required replacement.

Heat-Treating Furnaces

Furnaces for heat-treating are constantly being improved, both in design and construction. The metallurgical engineer is endlessly alert for innovations that will do his work faster, better and more economically.

Rolling Tube Furnace

One of the most important functions of industrial furnaces is to heat uniformly. *Lee Wilson Sales Corp.*, Cleveland, has developed a furnace for heating rollable objects which, it is said, possesses a high degree of heat uniformity.

The heating elements and conveyor of the furnace are one and the same. They consist of alloy heat resisting tubes rotated close together on a slight incline (adjustable) into which gas is fired at one end, the same as any conventional radiant tube.

The material to be heated such as projectiles, stud bolts, piston pins, brass extrusion slugs and any other rollable objects are delivered by magazine pusher feed or hand feed into the grooves between the heater-conveyor rolls and rotated quite rapidly as they progress slowly through the heating chamber, the rate of travel depending on the angle of inclination of the furnace toward the discharge end.

At the discharge end the rolls taper to allow sufficient space between them for the material to drop through sealed chutes to the quench tank.

The advantages of this method of heating are: (a) The furnace chamber is small in cross section and sealed off from the products of combustion and the outside air so that "protective" atmospheres can be admitted and surround the material as it travels through the furnace.

(b) The material being heated is rotated rapidly as it travels slowly endwise and is in direct contact with the radiant heating and conveyor tubes so that it heats rapidly and uniformly.

(c) The capacity of the furnace is in proportion to the number of roller tubes side by side, these being of standardized diameter and length and easily added by units in the original design.

Controlled Atmosphere Pit Furnace

Following up the introduction of an extra-deep controlled atmosphere pit type furnace, *Sentry Co.*, Foxboro, Mass., has recently brought out a smaller size in a similar unit.

Shorter tools or tools that require the hardening of a short end only can now be handled in a vertical position to eliminate any tendency to warp or to change shape when being heated. The atmosphere produced is the correct neutral atmosphere for alloys of molybdenum, cobalt or tungsten high speed steels.

The furnace has a maximum rating of 16 kw. with a normal operating consumption of 4-8 kw. per hr. Heating time from cold to 2350 deg. F. is 1 hr. The steel shell is of rugged design, and construction and the furnace is amply insulated for 2500 deg. F. operation.

Heating elements spaced alongside the muffle provide uniform muffle temperature. Shielded electrical terminals of a patented air-cooled design eliminate the necessity for a water-cooled terminal system.

The electrical design permits direct connection to either 110 v. or 220 v. supply without the use of a transformer.

Annealing Furnace

A modern, 24-ft. annealing furnace has recently been installed by *Jos. T. Ryerson & Son, Inc.*, Chicago, for annealing their stock steel products after they have been flame cut. Usually it is not necessary to anneal after flame cutting. However, with some types of steel, occasionally in the case of plates, and in some situations this is desirable.

Though 24 ft. long, the furnace can be divided into 3 sections. Each of the 3 furnaces may be used as a separate unit, making possible a prompt annealing service. The furnace has a structural steel framework and is lined with a special heat resisting material. It is crane-served and so situated that steel to be annealed can be quickly transported to the furnace from any part of the plant. The furnace is gas fired.

The annealing process most frequently used consists of cooling the steel very slowly, from a temperature slightly above its upper critical point. Control of the temperature, length of time in which the steel is held at various temperature, and rate of cooling are all extremely important in assuring the desired results.

Manganese Production Increase

Definite assurance of a possibility of greatly increased manganese production from domestic sources came from a report that the *Bur. of Mines* has been successful in producing concentrates with high manganese content ores from the low-grade deposits in the Las Vegas (Nev.) area.

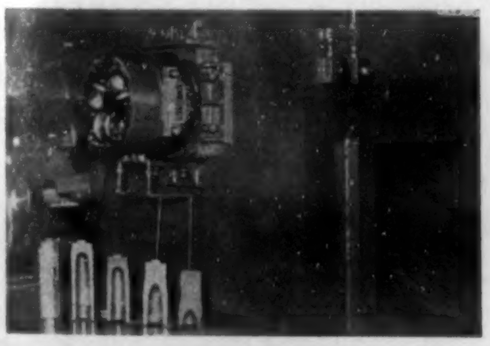
The first unit of the comprehensive group of pilot plants built by the Bur. of Mines at Boulder City, Nev. under a defense appropriation has started operations. A test run just concluded has demonstrated definitely the applicability of a process developed in the Bureau laboratories for supplying a portion of the defense requirements of manganese from domestic sources.

Manganese is one of the most vital strategic metals as far as this country is concerned, the Bureau pointed out, because about 12½ lbs. are needed for the production of every short ton of steel, and because substitution would be difficult. The United States produces only about 3% of its total needs of this ore, the remainder coming from abroad.

Shell Forging Machine

A four-stage completely automatic continuous-operation shell forging machine designed to produce from 240 to 300 finish-drawn 90 mm. shell forgings per hr.—directly from hot steel billets—is announced by *Clearing Machine Corp.*, Chicago.

Eliminating manual handling of the shell forging from the placing of the hot billet in the de-scaler until the finished drawn forging is ejected onto a cooling conveyor, the new machine requires less men to operate while producing from 3 to 5 times as many shell per hr. as on conventional upsetting machines.



In addition to combining in one automatic machine operations frequently performed separately, the new forging machine embodies a number of other innovations including a rotary indexing die table, self-aligning punches and mandrel with automatic stripping, combination roller and ring dies for final drawing of the shell, automatic cooling of the punches and mandrel between each operation, and an automatic lubricating system for dies and punches designed for use of the new shell forging lubricants containing "dag" colloidal graphite now being made available nationally by major oil companies.

In the new press, a steel billet is converted into a finish-drawn shell in 4 operations, as shown in the illustration. In the first operation, the billet is slightly upset to fit it firmly in the die and at the same time is lightly pierced. In the second, piercing is continued and the billet is changed from a square to a round form. In the third, piercing of the cavity is completed. The fourth operation consists of drawing the shell.

All three piercing operations take place without the work being removed from the die in the rotary indexing table. Following piercing, the work is automatically transferred from the die table to the drawing dies by means of a transfer carrier.

Largest Magnetic Pulley

Dings Magnetic Separator Co. announced recently the construction of a huge magnetic pulley, 48 in. in diam. and 63-in. face width. This, the manufacturer said, is the largest commercial magnet ever built. It will be applied as a magnetic head pulley in a coal conveyor belt, for the automatic extraction of tramp iron.

The separator has a total weight of 18,000 lbs. 5,900 lbs. of copper magnet wire was used. Coil covers and end rings are constructed of bronze. The weight of bronze used was over 1,800 lbs.

Time Control

A new time delay relay particularly convenient for such applications as setting heat-treating cycles and as an automatic switch-off for X-ray units is being marketed by *Eagle Signal Corp.*, Moline, Ill.

The relay possesses a 4-in. diam. clock face dial and time set pointer for convenience in making timing adjustments. It also has its own cycle initiating push button, which is locaed in the center of the time set adjusting knob.

One of the features of the device is that time settings remain fixed for repeated time intervals until the time set knob is turned to a new setting.

Personals

Henry A. Strow, formerly employed by the Udylite Corp. as maintenance service engineer, has been appointed chief chemist of MacDermid, Inc., Waterbury, Conn. . . . *Erich Fetz* is now chief metallurgist of C. O. Jelliff Mfg. Corp., Southport, Conn.

Naaman H. Keyser has joined the research staff at Battelle Memorial Institute, Columbus, Ohio and has been assigned to metallurgical research. . . . *L. W. Wallace* has been appointed vice president on the staff of Trundle Engineering Co. He was formerly with Crane Company, Chicago, as director of engineering and research.

Meetings and Expositions

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Louisville, Ky. Oct. 12-15, 1941.

STEEL FOUNDERS SOCIETY OF AMERICA, fall meeting. Hot Springs, Va. Oct. 13-14, 1941.

AMERICAN SOCIETY OF CIVIL ENGINEERS, fall meeting. Chicago, Ill. Oct. 15-17, 1941.

AMERICAN SOCIETY OF TOOL ENGINEERS, semi-annual meeting. Toronto, Canada. Oct. 16-18, 1941.

AMERICAN FOUNDRYMEN'S ASSOCIATION, regional foundry conference. West Lafayette, Ind. Oct. 17-18, 1941.

AMERICAN WELDING SOCIETY, annual meeting. Philadelphia, Pa. Oct. 19-23, 1941.

AMERICAN GEAR MANUFACTURERS ASSOCIATION, semi-annual meeting. Chicago, Ill. Oct. 20-23, 1941.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, fall meeting of Institute of Metals Div. and Iron & Steel Div. Philadelphia, Pa. Oct. 20-22, 1941.

AMERICAN GAS ASSOCIATION, annual convention. Atlantic City, N. J. Oct. 20-24, 1941.

AMERICAN SOCIETY FOR METALS, annual meeting. Philadelphia, Pa. Oct. 20-24, 1941.

NATIONAL METAL CONGRESS AND EXPOSITION. Convention Hall, Philadelphia, Pa. Oct. 20-24, 1941.

WIRE ASSOCIATION, annual meeting. Philadelphia, Pa. Oct. 20-24, 1941.

SOCIETY OF AUTOMOTIVE ENGINEERS, aircraft production meeting. Los Angeles, Calif. Oct. 30-Nov. 1, 1941.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, annual meeting. Virginia Beach, Va. Nov. 3-5, 1941.

AMERICAN PETROLEUM INSTITUTE, annual meeting. Nov. 3-7, 1941.

● A new series of standard boring tools with round shanks has just been announced by *McKenna Metals Co.*, Latrobe, Pa. These new tools have the same tool angles as other standard boring tools of the same company, a feature of which is the 12° positive back rake to compensate for the negative effect of the tool being held at height one-half the height of the shank above center.

Heat Treatment of Molybdenum High Speed Steels*

When the OPM declared a shortage of tungsten last June, metallurgical engineers in industry as well as those connected with the government tackled the problem of relieving that shortage with deadly earnest. For defense industries needed high speed tools, and high speed tools required tungsten. Since tungsten was running low, a suitable alternative had to be found in a hurry. The obvious answer was molybdenum high speed steel, which had already proven its virtues as a high speed tool steel.

From the special committees appointed by the OPM came the following report pertaining to the proper methods for treating molybdenum high speed steel to produce its highest efficiency. This report has already received rather wide publicity, but because of its extreme importance to the metallurgical engineering field, the most vital parts of it are published here.

It should be borne in mind that where hardening equipment is available in which decarburization can be controlled, there is no particular problem involved in replacing the tungsten high speed steel with the proper molybdenum high speed steel. There are differences in hardening temperatures and timing cycles, but the broad general principles are similar. Where proper equipment does not exist, the special precautions indicated below should be helpful.

The compositions for molybdenum high speed steels as given in Table I, include only those steels most widely used and established for general commercial tool applications. There are additional compositions which are used for special applications. Since they require special heat treatment to properly handle, their use is not discussed in this practice.

For those who are not skilled in handling molybdenum high speed steels and who do not have decarburization under good control, it is recommended that at present they adopt the following procedure:

(1) Use the required substitution of molybdenum high speed steels, selecting the type that will produce the best results and give the least trouble in working. The smaller tools are heat treated by shorter cycles and thus the general hazards are less.

(2) Proceed on the basis that steels of Type III decarburize less than steels of Type I or II. In most cases, steels of Type III can be treated without surface protection in the same equipment used for tungsten high speed steels.

(3) Consult with the firms from whom you purchase your high speed steels for their best advice in the light of your particular problem.

(4) Take steps to obtain modern, efficient hardening equipment on the premise that regardless of the kind of high speed steel being hardened, proper hardening promotes better tool life and better tool life in itself is a big step in conservation.

*Prepared by a special committee of the OPM: N. I. Stotz, Chairman, J. H. McCadie, W. H. Wills, F. L. Woodside & J. E. Donnellan, Secretary.

Forging

These steels can be forged like the tungsten type but at a slightly lower temperature, see Table II. When heating the molybdenum high speed steels for forging, they should be held in the furnace for the shortest time possible at the forging temperature.

Like all types of high speed steel, large pieces should be preheated to 1000-1200 deg. F. before heating to the forging temperature.

Slightly oxidizing atmospheres are preferred when no protective coating is used. No protection is necessary for ordinary sized forgings unless long heating cycles are involved. Borax is a very effective coating but has the disadvantage of making the surface of the steel very slippery at the forging temperature so the operator should take due precautions. To minimize the fluxing action on the furnace refractories, an excess of borax should be avoided.

After forging, it is desirable to cool slowly to about 300 deg. F. to avoid cracking from forging strains. This can be accomplished by furnace cooling or burying in lime, mica, or dry ashes, etc. Tools that have been forged should be machined or rough ground, after annealing, to remove

TABLE I

Compositions for Molybdenum High Speed Steels				
	Type I Molybdenum-Tungsten *a*	Type I Molybdenum-Tungsten *b**	Type II Molybdenum-Vanadium	Type III Tungsten-Molybdenum
C	.70– .85	.76– .82	.70– .90	.75– .90
W	1.25–2.00	1.60–2.30	....	5.00–6.00
Cr	3.00–5.00	3.70–4.20	3.00–5.00	3.50–5.00
V	.90–1.50	1.05–1.35	1.50–2.25	1.25–1.75
Mo	8.00–9.50	8.00–9.00	7.50–9.50	3.50–5.50
Co	See footnote	4.50–5.50	See footnote	See footnote

* Cobalt may be used in any of these steels in varying amounts up to 9.00% and the vanadium may be as high as 2.25%. When cobalt is used in Type III, this steel becomes susceptible to decarburization. As an illustration of the use of cobalt, Type Ib is included. This is steel T10 in the U. S. Navy Specification 46S37, dated November 1, 1939.

possible surface defects and to reduce the amount of grinding after hardening.

Heat Treatment

Annealing — Like tungsten high speed steels, these steels should be annealed after forging and before hardening, or when re-hardening is required. Box annealing is always preferable. When annealing partially finished tools, and generally when surface protection is of prime importance, it is recommended that cast iron chips or other mild source of carbon be used for packing material.

Heat slowly and uniformly to the temperature given in Table II, soak thoroughly and then cool slowly in the furnace. The steel should not be taken from the furnace until it is below 1000 deg. F.

After machining and before hardening it may be necessary to relieve harmful machining strains by annealing at 1150 to 1350 deg. F.

Hardening—The general method of hardening molybdenum high speed steels resembles that followed with 18-4-1, but the hardening temperatures (Table II) are lower and more precautions must be taken to avoid decarburization especially on tools when made from Type I or II when the surface is not ground after hardening. Salt baths and atmosphere controlled furnaces represent an excellent type of equipment for hardening molybdenum high speed steel. The use of coke fires or the blacksmith forge is not recommended for hardening any high speed steel, but if this type of equipment is all that is available, Type III may be so treated if an excess of air is avoided. However, simple surface protection in such equipment is safer practice even in the case of tungsten high speed steels.

The usual method is to preheat uniformly in a separate furnace to 1250 to 1550 deg. F. and transfer to a high heat furnace maintained at the hardening temperatures (see Table II).

When heated in open fire or in furnaces without atmosphere control, these steels do not sweat like 18-4-1. Consequently, the proper time in the high heat chamber is a matter of experience. This time approximates that used with 18-4-1 although slightly longer when the lower part of the hardening range is used. Much can be learned by hardening preliminary test pieces and checking up on the hardness fracture and structure. It is difficult to state exact heating time as this is affected by temperature, type of furnace, size and shape, and furnace atmosphere.

Rate of heat transfer is most rapid in salt baths, and slowest in controlled atmosphere furnaces with high carbon monoxide content.

Quenching—Quench the tool in oil, air or molten bath. To reduce the possibility of breakage and undue distortion in intricately shaped tools, it is advisable to quench in a molten bath at approximately 1100 deg. F. The tool may be quenched in oil and removed while still red or at approximately 1100 deg. F. The tool is then cooled in air to room temperature and tempered immediately to avoid cracking.

Straightening — When straightening is necessary, it should be done after quenching and before cooling to room temperature prior to tempering.

Tempering—Reheat slowly and uniformly to 950-1100 deg. F. For general work, 1050 deg. F. is most common. Hold at temperature at least 1 hr. Two hrs. is a better safe minimum and 4 hrs. is maximum. The time and temperature depend on the hardness and toughness required. Where tools are subjected to more or less shock, multiple temperings are suggested.

*Salt Bath Furnaces**

As already mentioned, the electric salt bath when properly controlled eliminates decarburization and is satisfactory for all types of molybdenum high speed steels.

In general, immersed electrode furnaces are being used where there is sufficient production to keep furnaces operating at a reasonable capacity. There are on the market today several types of immersed electrode salt bath furnaces and several types of salt baths. As a guide to those who are considering purchasing or installing such equipment, it is recommended that the selection of this equipment be made to suit their own production requirements from the equipment recommended.

The immersed electrodes generate heat directly in the molten salt bath itself by the electrical resistance of the bath material, and produce a positive circulation of the bath, due to the internal stirring action caused by the electrical flow between the electrodes. This stirring action increases the speed of heating and eliminates local overheating thus aiding close temperature control, which is always advantageous. A properly selected and maintained salt bath prevents scaling or oxidation of the work, and also when properly controlled prevents surface decarburization.

Decarburization or pitting in the high heat salt bath is usually caused by the presence of oxides. However, the manufacturers of salt baths supply a neutral bath containing a suitable deoxidizer or rectifier for the bath, which is sufficient to keep the bath free from oxides under normal operating conditions.

Under abnormal operating conditions, where a sufficient amount of new salt has not been added, it becomes necessary to make supplementary additions of rectifier material supplied by the manufacturer. These manufacturers will supply information as to procedure for simple chemical control to maintain the salt bath in a suitable condition.

The recommended temperatures for hardening in the salt baths of molybdenum high speed steels have been given in Table II. Briefly, the procedure is as follows:

A. Clean work free from scale, rust, oil, grease and moisture. Use either solvent degreaser or suitable alkaline cleaner, followed by a clean hot water rinse, and thorough drying. Every precaution must be taken to prevent moisture on tools going into the salt, as wet tools may cause a steam explosion, burning the operator.

B. Immerse in preheat salt bath, temperature 1500-1550 deg. F. Allow sufficient time for work to reach temperature of bath.

C. Transfer to high heat salt bath. Temperature 2150-2250 deg. F. Allow sufficient time for work to reach temperature of bath,

Prepared by a special committee of the OPM: A. F. Holden, Chairman, James McElgin, J. N. Bourg, W. J. Levy & J. E. Donnellan, Secretary.

TABLE II

Heat Treatment of Molybdenum High Speed Steels

	Type I Molybdenum-Tungsten a and b	Type II Molybdenum-Vanadium	Type III Tungsten-Molybdenum
Forging	1850–2000°F.	1850–2000°F.	1900–2050°F.
Not below	1600°F.	1600°F.	1600°F.
Annealing	1450–1550°F.	1450–1550°F.	1450–1550°F.
Strain Relief	1150–1350°F.	1150–1350°F.	1150–1350°F.
Preheating	1250–1500°F.	1250–1500°F.	1250–1550°F.
Hardening	2150–2250°F.	2150–2250°F.	2175–2275°F.
Salt	2150–2225°F.	2150–2225°F.	2150–2250°F.
Tempering	950–1100°F.	950–1100°F.	950–1100°F.

Under similar conditions Type b requires a slightly higher hardening heat than Type a. The higher side of the hardening range should be used for the large sections and the lower side for the small sections.

plus proper soaking time at temperature.

D. Transfer to quench bath. Temperature 1100-1200 deg. F. Allow sufficient time to cool to bath temperature. Two to 5 minutes will suffice, depending upon size. Remove from salt bath and cool in air or oil. Quenching in oil is not recommended for work of intricate design or work where distortion is apt to occur.

E. After work has cooled to *room temperature,* wash off all adhering salts in a hot alkaline cleaner. If the work is to be tempered in a furnace (air atmosphere), the work should be shot or sand blasted or cleaned by other methods, to insure removal of all adhering salts. If this is not done, the salt will attack the work during the tempering. If a salt bath is used for tempering, the work need only be cleaned in a hot alkaline solution or hot water.

The effects of salt bath hardening are as follows:

A. The molybdenum high speed steels when hardened in salt baths are entirely surrounded by neutral molten salt. A salt film is retained on the tool throughout the hardening procedure, thus preventing decarburization or scaling.

B. The salt bath hardening method provides uniform heating; and this generally results in less distortion. All sections of intricately shaped tools are uniformly heated by this method. The salt bath permits selective hardening.

C. When a salt bath is properly selected and properly maintained, there is no chemical attack by this bath on the molybdenum high speed steels. The original surface of the steel is retained.

Molybdenum high speed steels will take all the special surface treatments, including nitriding when immersed in molten cyanide, that are applied to tungsten high speed steels for certain applications.

*Controlled Atmosphere Furnaces**

In addition to the use of high temperature salt baths, atmosphere controlled furnaces satisfy the demand for surface protection against decarburization. These furnaces are now available in both electric and fuel-fired types where the atmosphere is independent of the source of heat. This permits control of the atmosphere in contact with the work to be treated. Small and delicate pieces can be given the heat treatment that will develop the good properties of the steel without injuring the surface or overheating thin projections.

The ideal atmosphere is one that is not harmful to the steel. The atmospheres commonly used are products of combustion and inert gases both of which have been cleaned of undesirable constituents and closely regulated as to composition.

An atmosphere for the successful heat treatment of molybdenum high speed steels must be: 1. Capable of preventing decarburization; 2. Capable of preventing excessive carburization, which will cause wrinkling of the surface, melting of the edges, pitting and embrittlement of the cutting edge; and 3. Capable of preventing harmful scale or oxidation.

To prevent the above changes from taking place, the atmosphere for the preheat temperature is just as important as the atmosphere for the high heat temperature. The atmosphere for the preheat temperature should have the same characteristics as the atmosphere for the high heat temperature. A high heat furnace equipped with an atmosphere for satisfactory hardening will be of no value if the proper atmosphere is not used on the preheat furnace.

Coatings

Borax may be applied by lightly sprinkling over the steel when heated to a low temperature (1200-1400 deg. F.). Small tools heated as above may be rolled in a box of borax. Another method more suitable for finished tools is to apply the borax or boric acid in the form of a supersaturated water solution. In such cases the tools are immersed in the solution at 180-212 deg. F., or it may be applied with a brush or spray. Pieces so treated are heated as usual with care taken in the handling to insure good adherence.

Special protective coatings or paints when properly applied have been found extremely useful. They do not fuse or run at the temperatures used and therefore do not affect the furnace hearth. When applying these coatings, it is necessary to have a surface free from scale or grease to insure good adherence.

* Prepared by a special committee of the OPM: C. L. Hayes, chairman, P. B. Crocker, W. M. Hepburn, Norbert Koebel, Karl Ness and J. E. Donnellan, Secretary.

METALLURGICAL ENGINEERING

shop notes

Determining Depth of Case

The determination of the case depth of carburized work is a widely performed but often difficult operation. With the ordinary fracture methods, the line of demarcation between case and core is not always easy to distinguish. This is especially true of high alloy steels, and of plain carbon steels that have not been given the proper core-refining treatment.

The following method is very simple, gives clear results and does not entail the use of the customary chemical etching reagents.

The fractured carburized test piece or component is heated and quenched in the ordinary way and broken to reveal the fracture. The broken part is then gently heated in a flame from a gas torch or Bunsen burner, care being taken to concentrate the heat some distance away from the fracture.

The piece should be removed from the flame from time to time and the fracture examined for any color change. As soon as the first positive change in color becomes visible, the heating should be stopped and the part quenched immediately in water. With a little practice it will be a simple matter to stop the heating at the right stage.

After the moisture has been evaporated, the case and the core will be seen to stand out in colorful contrast. The evaporation of the water will be accelerated by taking the quenched part from the water while it is still warm. The best results are obtained when the core reaches a bright brick-red color; at this stage the case will stand out clearly as a blue ring surrounding the core.

The process is not difficult to carry out and very creditable results may be obtained even at the first trial. The equipment required is of the very simplest kind and is to be found invariably in every heat-treating shop. The results obtained are so distinct and satisfying that the few extra minutes required will be well repaid by the certainty with which the case depth is determined.

The adoption of this method will also result in the elimination of eyestrain, which is inevitable when one is trying to estimate the depth of case where the case and the core are of the same color. The case and the core stand out distinctly and even under considerable magnification the line of demarcation is clearly defined.

—*Wild-Barfield Heat-Treatment Journal,* June 1941

Simplified Identification Markings

by C. O. Malmstrom

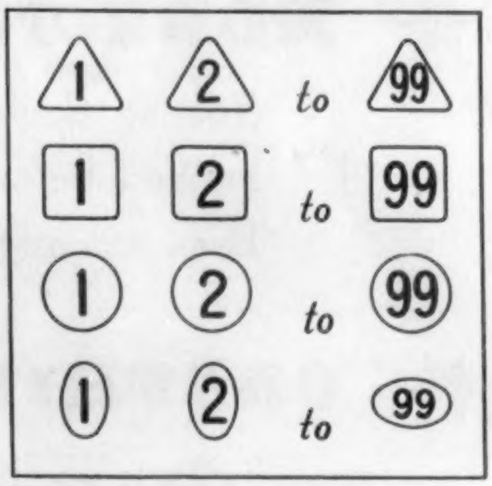
New Method Steel Stamps, Inc.

Many times situations arise in metal-working shops, which require a convenient and simple means of identifying metal parts or of specifically marking the work of individual employees or inspectors. It is very easy to become entangled in a confused mess, particularly where a plant is operating on a triple-shift basis, or where there are a number of different types of workers requiring identification steel stamps.

It is essential that the system employed be accurate and at the same time flexible and not unwieldy. A very simple method of avoiding a mix-up is to use several sets of steel stamps. Each set can be numbered from 1 to 99 and the numbers enclosed in identifying shaped borders. Thus, one group has the numbers enclosed in a square, another in a triangle, another in a circle, and still another—if needed—in an oval. Any number of border designs can be used.

This set-up makes possible assigning identical numbers with different borders to different inspectors or operators. Where 3 shifts are employed, each shift can be given a different border design. In cases where a number of different operations are performed in a fabricating process, it is sometimes convenient to have a means of identification that separates the various types of processing workers.

Thus, the identification symbols of welders can be divided according to the various types or classes by this means. For example, manual arc welders might have a circle about their symbol, automatic machine welders could have their symbol enclosed in a triangle, etc. The different classes of welders might be distinguished through the use of various border designs. Many other identification problems can be solved by employing this simple system.



Typical Sets of Marking Designs

Holes in piston pins, always difficult to clean after hardening, may be efficiently freed of scale by airless blast cleaning. An added advantage of this method is that it reveals "soft spots," which show up as gray areas after blast cleaning.

—American Foundry Equipment Co.

PREVIEW SECTION

of the

NATIONAL METAL CONGRESS

Contents

INTRODUCTION

Unusual importance is attached to the National Metal Congress this year—the 23rd of these annual events. Because metals and their alloys are so essential in a world war, and particularly as regards the defense of the United States, this particular congress is especially timely. This year it will be held in Philadelphia—Oct. 20 to 25 inclusive. There are evidences from preliminary announcements that this year's Congress will be the largest ever held, eclipsing the record one held last year in Cleveland.

O. E. HARDER
PRESIDENT
A.S.M.

The Participating Societies

As in the recent past, four technical societies cooperate in the Congress: The American Society for Metals, sponsor of the whole Congress; the two metal divisions of the American Institute of Mining and Metallurgical Engineers; the American Welding Society; and the Wire Association.

Nearly 170 papers, lectures and discussions have been scheduled for the technical program of the four societies—all contributed by leading authorities in the metal industries.

A "Production Clinic" will be a feature of the Congress, each afternoon of the five days being set aside for a frank discussion of the problems in the Defense Program, participated in by ranking members of several departments of the U. S. Government.

The Exposition

The National Metal Exposition is predicted to be the largest in its history. It will be held in the Convention Hall and Commercial Museum of Philadelphia. Exhibitors, at least 300, are cooperating to make the Congress of service to the nation by exhibiting the latest aids for speeding production of defense materials.

BRADLEY STOUGHTON
PRESIDENT-ELECT
A.S.M.

Lectures

Of the scheduled lectures, the main feature is always the Campbell Memorial Lecture—delivered this year by Dr. Robert F. Mehl, director, Metals Research Laboratory, Carnegie Institute of Technology, Pittsburgh.

Eight educational lectures will be delivered during the week—following a custom established 6 yrs. ago. A course of 5 lectures on "Heat Flow of Metals" will be delivered each day at 5 P. M. by J. B. Austin, U. S. Steel Corp. Research Laboratory, Kearny, N. J. Three lectures on Monday, Wednesday and Friday at 8 P. M. will be delivered by S. R. Williams of Amherst College on "Hardness and Hardness Measurements".

In General

Arrangements have been made for plant visitations—the Philadelphia territory has numerous ferrous and non-ferrous organizations of interest to delegates and visitors.

On other pages will be found the tentative technical programs of the four societies and a list of the exhibitors.

CONVENTION HALL AND
COMMERCIAL MUSEUM,
PHILADELPHIA

Technical Program of the

American Society for Metals

One of the leading technical features of the National Metal Congress is the program of papers presented at the sessions of the American Society for Metals.

The tentative program this year is made up of about 60 papers presented at 12 different sessions. All of these papers will be delivered at simultaneous sessions each morning. This is a departure from the usual custom of sessions each morning and afternoon. The reason for this change is that the afternoons will be devoted to national defense group meetings and forums on such subjects as conservation and substitutions in the metal field. These will be participated in by Government officials and production executives of defense equipment and material manufacturers as well as by outstanding metallurgical engineering authorities on the manufacture, production and fabrication of metals and their alloys, so essential to the whole Defense Program.

The Campbell Memorial Lecture, always a highlight among the technical features, will be delivered Wednesday morning, Oct. 22, by Dr. R. F. Mehl, Carnegie Institute of Technology. Educational lectures are scheduled during the week by two authorities: J. B. Austin of the research laboratory of the U. S. Steel Corp. and by S. R. Williams of Amherst College.

The annual banquet is scheduled for Thursday evening at the Hotel Benjamin Franklin.

The tentative program for the A. S. M. convention is as follows:

R. F. MEHL

CAMPBELL MEMORIAL LECTURER

MONDAY MORNING, OCT. 20

"The Nickel-Molybdenum System," by F. H. Ellinger, General Electric Co.

"The Acicular Structure in Nickel-Molybdenum Cast Irons," by R. A. Flinn, American Brake Shoe & Foundry Co., Morris Cohen and John Chipman, Massachusetts Institute of Technology.

"Elimination of the Apparent Hot Brittleness of 0.50 per cent Mo Steel," by C. L. Clark, Timken Roller Bearing Co., and J. W. Freeman, University of Michigan.

"Some Properties of Phosphorus-Titanium Steels," by G. F. Comstock, The Titanium Alloy Mfg. Co.

"Wear Tests on Ferrous Alloys," by O. W. Ellis, Ontario Research Foundation.

SIMULTANEOUS SESSION

"The Effect of Microstructure Upon the Work Hardening Characteristics of a 0.74 per cent C Strip Steel," by N. P. Goss and Wm. Brenner, Jr., Cold Metal Process Co.

"Problems in the Drawability of Deep Drawing Sheets," by M. Asimow, Central Metal Products Co., and J. N. Crombie, Carnegie-Illinois Steel Corp.

"A Study of Cutting Oils With and Without Added Sulphur," by O. W. Boston and J. C. Zimmer, University of Michigan.

"Some Properties of Sintered and Hot Pressed Copper-Zinc Powder Compacts," by C. G. Goetzel, American Electro Metal Corp.

"Homogenization of Copper-Nickel Powder Alloys," by F. N. Rhines and R. A. Colton, Carnegie Institute of Technology.

SIMULTANEOUS SESSION

"Magnetic Methods for Determining Carbon in Steel," by B. A. Rogers, Karl Wentzel and J. P. Riott, U. S. Bureau of Mines.

"Application of Oscillograph to Determination of Cooling Rates of Quenched Steels," by C. R. Austin, R. M. Allen and W. G. Van Note, Pennsylvania State College.

"The Influence of Alloying Elements on the Critical Points of Steels as Measured by the Dilatometer," by R. N. Gillmor, General Electric Co.

"X-Ray Study of the A_3 Point of Pure Iron Using the Geiger-Muller Counter," by A. P. Wangsgard, Pennsylvania State College.

"Heat Etching as a General Method for Revealing the Austenite Grain Size of Steels," by O. O. Miller and M. J. Day, United States Steel Corp.

TUESDAY MORNING, OCT. 21

"Hardenability Testing of Low Carbon Steels," by R. C. Frerichs and E. S. Rowland, Timken Roller Bearing Co.

"Hardenability of Shallow-Hardening Steels," by C. B. Post, O. V. Greene and W. H. Fenstermacher, Carpenter Steel Co.

"The Effect of Carbon Content and Cooling Rate on the Decomposition of Austenite During Continuous Cooling of Plain Carbon Steels," by R. F. Thomson and C. A. Siebert, University of Michigan.

"The Tensile Properties of Pearlite, Bainite and Spheroidite," by M. Gensamer, E. B. Pearsall, W. S. Pellini and J. R. Low, Jr., Carnegie Institute of Technology.

"Effects of Initial Structure on Austenite Grain Formation and Coarsening," by M. Baeyertz, Carnegie-Illinois Steel Corp.

(Continued on page 542)

(Continued from page 540)

SIMULTANEOUS SESSION

"Balancing the Composition of Cast 25 per cent Cr, 12 per cent Ni Type Alloys," by J. T. Gow and O. E. Harder, Battelle Memorial Insitute.

"The Rate of Formation of Tin-Iron Alloy During Hot Dip Tinning as Measured by a Magnetic Method," by A. U. Seybolt, Battelle Memorial Institute.

"The Role of Nitrogen in 18-8 Stainless Steel," by H. H. Uhlig, General Electric Co.

"The Cyclic Temperature Acceleration of Strain in Heat Resisting Alloys," by G. R. Brophy and D. E. Furman, International Nickel Co.

"The Influence of Stress on the Corrosion Pitting of Steel in Distilled Water, by D. J. McAdam, Jr., and G. W. Geil, National Bureau of Standards.

SIMULTANEOUS SESSION

"Urea Process for Nitriding Steels," by R. P. Dunn, Electro Manganese Corp., W. B. F. Mackay, Royal Canadian Air Force, and R. L. Dowdell, University of Minnesota.

"The Kinetics of Graphitization in White Cast Iron," by H. A. Schwartz, National Malleable and Steel Castings Co.

"Effects of Small Amounts of Alloying Elements on Graphitization of High Purity Hyper-Eutectoid Steels," by C. R. Austin, Pennsylvania State College, and B. S. Norris, United States Pipe and Foundry Co.

"Effect of Cooling Temperature After Carburizing on Reheated and Single Quenched Steel," by O. W. McMullan, Youngstown Sheet and Tube Co.

"The Precipitation Reaction in Aged Cold-Rolled Brasses: Its Effects on Hardness, Conductivity, and Tensile Properties," by R. H. Harrington and T. C. Jester, General Electric Co.

WEDNESDAY MORNING, OCT. 22

ANNUAL MEETING OF THE AMERICAN SOCIETY FOR METALS

1941 EDWARD DE MILLE CAMPBELL MEMORIAL LECTURE, by R. F. Mehl, Carnegie Institute of Technology.

THURSDAY MORNING, OCT. 23

SYMPOSIUM ON CONTROLLED ATMOSPHERES

"Fundamental Features of Controlled Atmospheres, Particularly for the Heat Treatment of Steel," by H. W. Gillett and B. W. Gonser, Battelle Memorial Institute.

"Chemical Equilibrium as a Guide in the Control of Furnace Atmospheres," by J. B. Austin and M. J. Day, United States Steel Corp.

"Prevention of Oxidation Type of Reaction of Ferrous Metals," by A. G. Hotchkiss and H. M. Webber, General Electric Co.

"Prevention of Oxidation Type of Reaction in the Heat Treatment of Copper and Its Alloys, by E. G. deCoriolis and William Lehrer, Surface Combustion Corp.

"The Heat Treatment of the Chromium-Carbon Stainless Steels," by W. E. Mahin and W. C. Troy, Westinghouse Electric & Mfg. Co.

SIMULTANEOUS SESSION

"The Effect of Strain Rate Upon the Tensile Impact Strength of Some Metals," by E. R. Parker and C. Ferguson, General Electric Co.

"Effect of Grain Size and Heat Treatment Upon Impact Toughness at Low Temperatures of Medium Carbon Forging Steel," by S. J. Rosenberg and D. H. Gagon, National Bureau of Standards.

"Low Temperature Impact Resistant Steel Castings," by N. A. Ziegler and H. W. Northrup, Crane Co.

"Dynamic Hardness Testing of Metals and Alloys at Elevated Temperatures," by Erich Fetz, C. O. Jelliff Mfg. Corp.

SIMULTANEOUS SESSION

"Microstructural Characteristics of High Purity Alloys of Iron and Carbon," by T. G. Digges, National Bureau of Standards.

"The Structure of Pearlite," by F. C. Hull, Westinghouse Electric & Mfg. Co., and R. F. Mehl, Carnegie Institute of Technology.

"The Interlamellar Spacing of Pearlite," by G. E. Pellissier, International Nickel Co., M. F. Hawkes, Carnegie Institute of Technology, W. A. Johnson, Westinghouse Electric & Mfg. Co., and R. F. Mehl, Carnegie Tech.

"The Martensite Thermal Arrest in Iron-Carbon Alloys and Plain Carbon Steels," by A. B. Greninger, General Electric Co.

"A Study of Martensite Formation by a Photometric Method," by E. R. Saunders, Union Carbide & Carbon Corp., and J. F. Kahles, University of Cincinnati.

FRIDAY MORNING, OCT. 24

SYMPOSIUM ON CONTROLLED ATMOSPHERES

"Atmospheric Control for the Prevention of Decarburization in Springs and Similar Products," by J. A. Comstock, Pratt & Whitney Aircraft Div.

"Methods for Determining the Degree of Carburization or Decarburization and Evaluating Controlled Atmospheres," by N. K. Koebel, Lindberg Engineering Co.

"Surface Effects Accompanying the Heating of Carbon Tool Steel in Oxidizing Atmospheres," by R. D. Stout and Toivo Aho, Lehigh University.

"Discussion of Equipment, Instrumentation and Economy," by E. E. Slowter, Battelle Memorial Institute.

"Atmospheric Control in the Heat Treatment of Aluminum Products," by P. T. Stroup, Aluminum Co. of America.

"Atmospheric Control in the Heat Treatment of Magnesium Products," by C. E. Nelson, Dow Chemical Co.

SIMULTANEOUS SESSION

"Electrical Resistance Method for the Determination of Isothermal Austenite Transformations," by F. B. Rote, International Nickel Co., W. C. Truckenmiller, A-C Spark Plug Div., General Motors Corp., and W. P. Wood, University of Michigan.

"The Tempering of Two High Carbon, High Vanadium High Speed Steels," by B. S. Lement and Morris Cohen, Mass. Inst. of Technology.

"The Transformation of Retained Austenite in High Speed Steel at Sub-Atmospheric Temperatures," by M. P. Gordon and Morris Cohen, Massachusetts Institute of Technology.

"Study of Dimensional and Other Changes in Various Die Steels Due to Heat Treatment," by G. M. Butler, Jr., Allegheny Ludlum Steel Corp.

"Hardening Characteristics of an Iron-Cobalt-Tungsten Alloy," by W. P. Sykes, General Electric Co.

SIMULTANEOUS SESSION

"The Over-All Linear Expansion of Three Face-Centered Cubic Metals (Al, Cu, Pb) From —190° C. to Near Their Melting Points," by J. W. Richards, Mt. St. Mary's College.

"The Temperature and Manner of Growth of Shatter Cracks in Steel Rails," by H. B. Wishart and E. P. Epler, Carnegie-Illinois Steel Corp., and R. E. Cramer, University of Illinois.

"The Carbon-Oxygen Equilibrium in Liquid Iron," by Shadburn Marshall, Remington Arms Co., and John Chipman, Mass., Inst. of Technology.

"The Solubility of Iron Oxide in Liquid Iron," by John Chipman, Massachusetts Institute of Technology, and K. L. Fetters, Carnegie Inst. of Tech.

"Rapid Temperature Measurements of Molten Iron and Steel With an Immersion Thermocouple," by Fulton Holtby, University of Minnesota.

Educational Lectures

"Heat Flow in Metals," by J. B. Austin, U. S. Steel Corp. Research Laboratory; *daily* at 5:00 P.M.

"Hardness and Hardness Measurements," by S. R. Williams, Amherst College; *Monday, Tuesday* and *Wednesday* at 8:00 P.M.

TO MOLYBDENUM HIGH SPEED STEELS

Crucible can Help you!

1

SELECT THE PROPER ONE OF "ALL THREE" MOLYBDENUM GRADES

To help you cooperate with O.P.M. General Preference Order M-14 (affecting the partial substitution of Molybdenum for Tungsten High Speed Steels), Crucible offers you the following three established grades.

REX MM (5.50% W, 4.00% Mo, 4% Cr, 1.50% V, .80% C), is the general-purpose substitute for REX AA and is recommended for lathe, planer and boring tools, reamers, hobs, milling cutters, drills and taps.

REX VM (8% Mo, 4% Cr, 2% V, .85% C), is primarily recommended for twist drills, taps, hack saws and slitting saws. It is also suitable for lathe, planer and boring tools, chasers, reamers, hobs and milling cutters. This grade contains no Tungsten.

REX TMO (1.50% W, 8.75% Mo, 3.75% Cr, 1.10% V, .80% C), is recommended for twist drills, taps, lathe, planer and boring tools, reamers, hobs and milling cutters.

2

RECOMMEND THE PROPER HEAT TREATING PROCEDURE

Crucible knows Molybdenum High Speed Steels . . . and how to treat them. This knowledge comes from years of constant research and use . . . against the day when Molybdenum High Speed Steels would be in urgent demand.

To help you get the most out of these Molybdenum steels—to help you heat treat them properly—Crucible invites you to call upon its nation-wide service organization, experienced representatives, technical engineers and metallurgists. They will gladly visit your plant, examine your equipment and recommend a heat treating procedure that should insure uniform, dependable performance.

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Technical Program of the

Metals Divisions of the A. I. M. E.

Fully up to previous high standards, the technical program of the Iron and Steel Division and the Institute of Metals Division of the A. I. M. E. consists of 21 papers by authorities in the various fields. The headquarters are at the Ritz-Carlton Hotel, where all sessions will be held, commencing on Monday morning, Oct. 20.

A feature of this convention will be a round-table discussion on "order-disorder phenomena" on Tuesday afternoon, Oct. 21, at which the chief speaker will be Dr. Wm. B. Shockley of the Bell Telephone Laboratory, New York.

The customary annual joint dinner of the two divisions will be held at the Ritz-Carlton on Tuesday evening, Oct. 21, at which an interesting speaker will be the feature.

The tentative technical program is as follows:

MONDAY MORNING, OCT. 20

INSTITUTE OF METALS DIVISION—COPPER AND TIN ALLOYS:

"Rates of High-temperature Oxidation of Dilute Copper Alloys," by F. N. Rhines, Asst. Prof. of Metallurgy, on Staff Metals Research Laboratory, Carnegie Institute of Technology; W. A. Johnson, Research Metallurgist, Westinghouse Research Laboratories; and W. A. Anderson, Research Assistant, Metals Research Laboratory, Carnegie Institute of Technology.

"Effect of Columbium on Some Annealing Characteristics of Copper and 80-20 Cupronickel," by Alan U. Seybolt, Metallurgist, Battelle Memorial Institute.

"Recrystallization and Precipitation on Aging of Tin-Bismuth Alloys," by J. E. Burke, Norton Co., Research Laboratories, and C. W. Mason, Professor Chemical Microscopy and Metallography, Cornell University.

"The Ferromagnetic Nature of the Beta Phase in the Copper-Manganese-Tin System," by Louis A. Carapella, Division of Physical Metallurgy, Naval Research Laboratory, and Ralph Hultgren, Asst. Prof. of Physical Metallurgy, University of California.

MONDAY MORNING, OCT. 20

IRON AND STEEL DIVISION—PHYSICAL CHEMISTRY OF STEEL MAKING:

"Silicon-Oxygen Equilibria in Liquid Iron," by C. A. Zapffe, Research Engineer and C. E. Sims, Supervising Metallurgist, Battelle Memorial Institute.

"Silicon Monoxide," by C. A. Zapffe, Research Engineer, and C. E. Sims, Supervising Metallurgist, Battelle Memorial Institute.

MONDAY AFTERNOON, OCT. 20

JOINT SESSION—PHYSICAL METALLURGY:

"Theory of Lattice Expansion Introduced by Cold-work," by Clarence Zener, Associate Professor of Physics, State College of Washington.

"Rapid Tension Tests Using the Two-Load Method," by A. V. de Forest, Professor Mechanical Engineering, Massachusetts Institute of Technology; C. W. MacGregor, Associate Professor, Applied Mechanics; and A. R. Anderson, Department of Mechanical Engineering, Massachusetts Institute of Technology.

"A New Method for Determination of Stress Distribution in Thin-Walled Tubing," by G. Sachs, Associate Professor, and G. Espey, Research Assistant, Case School of Applied Science.

TUESDAY MORNING, OCT. 21

INSTITUTE OF METALS DIVISION—BRASS:

"Effect of Cold-Work and Annealing upon Internal Friction of Alpha Brass," by Clarence Zener, Associate Professor of Physics; Howard Clarke, Graduate Student, State College of Washington; and Cyril Stanley Smith, Research Metallurgist, American Brass Co.

"Strength Distribution in Sunk Brass Tubing," by George Sachs, Associate Professor; G. Espey, Research Assistant; and G. B. Kasik, Graduate Assistant, Case School of Applied Science.

"Residual Stress in Sunk Cartridge Brass Tubing," by G. Sachs, Associate Professor, and G. Espey, Research Assistant, Case School of Applied Science.

"Micrographic Observations of Slip Lines in Alpha Brass," by R. G. Treuting, Graduate Student; and R. M. Brick, Instructor in Metallurgy, Hammond Metallurgical Laboratory, Yale University.

TUESDAY MORNING, OCT. 21

IRON AND STEEL DIVISION—IRON AND IRON ALLOYS:

"A Magnetic Determination of the A_3 Transformation Point in Iron," by B. A. Rogers and K. O. Stamm, U. S. Bureau of Mines.

"The Instability of Low-Expansion Iron-Nickel-Cobalt Alloys," by Irvin R. Kramer and Francis M. Walters, Jr., Naval Research Laboratory.

"Analysis of Mechanical Properties of Heat-Treated Steels," by J. S. Marsh.

"The Evaluation of Ductility of Steels for Welding," by A. B. Kinzel, Chief Metallurgist, Union Carbide and Carbon Research Laboratories, Inc.

TUESDAY AFTERNOON, OCT. 21

JOINT SESSION—ROUND TABLE ON ORDER-DISORDER PHENOMENA

Discussion of order-disorder by William B. Stockley, Bell Telephone Laboratories.

WEDNESDAY MORNING, OCT. 22

No session. Howe Memorial Lecture, A.S.M.

WEDNESDAY AFTERNOON, OCT. 22

INSTITUTE OF METALS DIVISION—MAGNESIUM AND ALUMINUM ALLOYS:

"Preferred Orientation in Rolled Magnesium and Magnesium Alloys," by P. W. Bakarian, Dow Chemical Co.

"Corrosion Studies of Magnesium and Its Alloys," by J. D. Hanawalt, C. E. Nelson, and J. A. Pelaubet, Dow Chemical Co.

"Relief of Residual Stress in Some Aluminum Alloys," by L. W. Kempf and K. R. Van Horn, Aluminum Research Laboratories, Aluminum Co. of America.

WEDNESDAY AFTERNOON, OCT. 22

IRON AND STEEL DIVISION—ALLOY STEEL:

"Mechanical Properties of Iron-Manganese Alloys," by F. M. Walters, Jr., I. R. Kramer, and B. M. Loring, Naval Research Laboratory.

"Influence of Chromium and Molybdenum on Structure, Hardness and Decarburization of 0.35 Per Cent Carbon Steel," by R. F. Miller and R. F. Campbell, Research Laboratory, U. S. Steel Corp.

"The S-curve of a Chromium-Nickel Steel," by Blake M. Loring, Naval Research Laboratory.

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Technical Program of the

American Welding Society

A technical program of broad scope has been prepared for the annual convention of the American Welding Society during the National Metal Congress. An impressive array of some 65 papers will be presented at 17 sessions on each day, commencing Monday morning, Oct. 20, and continuing through Friday, Oct. 25.

The headquarters of the Society, where all sessions will be held, are at the Bellevue-Stratford Hotel.

The annual banquet will be held this year at the headquarters, Thursday evening, Oct. 23.

The tentative technical program follows:

MONDAY MORNING, OCT. 20

Session on Weldability of Plain Carbon and Low Alloy Steels

"The Specification of Weldability of Steels," by A. B. Kinzel, Union Carbide and Carbon Research Laboratories.

"Weldability Tests of Nickel Steels," by C. E. Jackson and G. G. Luther, Naval Research Laboratory.

"Weldability of Steels," by W. H. Bruckner, University of Illinois.

MONDAY AFTERNOON, OCT. 20

Research Session—Non-Ferrous

"Study of the Effect of Core Wire Temper on the Quality of Welds in Monel, Nickel and Inconel," by F. G. Flocke and K. M. Spicer, The International Nickel Co., Inc.

"The Flow of Metal in Brazing Aluminum," by M. A. Miller, Aluminum Research Laboratories.

"Welding of Copper," by A. P. Young, College of Mining & Technology.

"The Spot Welding of Nickel, Monel and Inconel," by W. F. Hess and Albert Muller, Rensselaer Polytechnic Institute.

"The Contact Resistance of Pure Aluminum in Resistance Welding," by W. B. Kouwenhoven, Johns Hopkins University.

Shipbuilding Session

"Riveted Vs. Welded Galvanized and Corrosion Resisting Steel Smoke Pipes," by H. O. Klinke, U. S. Navy Yard.

"Machine Flame Cutting in Ship Construction," by E. R. McClung and H. L. Wagener, New York Shipbuilding Corp.

"Survey of Welding and Cutting in Ship Construction," by F. G. Outcalt and J. M. Keir, The Linde Air Products Co.

"Welding Applications in Naval Machinery," by H. W. Hiemke and J. D. Bert, Navy Department, Bureau of Ships.

Training Session

"Training of Welding Operators," Round-table discussion led by A. G. Bissell, Bureau of Ships, Navy Department.

"A.W.S. Minimum Requirements for the Training of Welding Operators," by A. B. Wrigley, Chairman of Committee.

"Training Welders for National Defense," by James A. Waln, Defense Training Program, U. S. Office of Education.

"Training of Oxy-Acetylene Welding and Cutting Operators," by D. E. Roberts, International Acetylene Association.

TUESDAY MORNING, OCT. 21

Fundamental Research Session—Arc Studies and Heat Flow

"Magnetic Arc Blow," by C. H. Jennings and A. B. White, Westinghouse Electric & Mfg. Co.

"Mechanism of Metal Transfer in the Arc," by L. J. Larson, Consulting Engr.

"Heat Flow in Arc Welding," by F. M. Mahla, M. C. Rowland, C. A. Shook, and G. E. Doan, Lehigh University.

Railroad Session

"Welding as Applied to Locomotive," by James Partington, American Locomotive Co.

"Design of the World's Largest Welded Flat Car," by H. M. Priest, Railroad Research Bureau.

"Welding Locomotives," by A. J. Raymo, Baldwin Locomotive Co.

"Pressure Butt Welding of Railroad Rails," by Lem Adams, Oxweld Railroad Service Co.

TUESDAY AFTERNOON, OCT. 21

Fundamental Research Session—Testing Methods

"Weld Inspection by Means of Infra-Red Light," by W. T. Tiffin, University of Oklahoma.

"Evaluating Welded Joints," by W. F. Hess, Rensselaer Polytechnic Institute.

"Methods of Testing Spot Welds," by R. E. Bowman, War Dept., Air Corps.

"Thermal Gradients in Spot-Welding Electrodes," by F. R. Hensel, E. I. Larsen and E. F. Holt, P. R. Mallory & Co.

Aircraft and Automotive Session

"Automotive Welding," by S. M. Spice, Buick Motor Division, Vaugn Fegley, A-C Spark Plug Co., and L. M. Skidmore, General Motors Institute of Technology.

"Production and Quality Control in Aluminum Alloy Spot Welding," by P. H. Merriman, The Glenn L. Martin Co.

(Continued on page 554)

Col. G. F. Jenks
President
A.W.S.

Technical Program of the

Wire Association

The Wire Association holds its annual meeting during the National Metal Congress at which about 12 papers have been scheduled. The sessions will all be held at the headquarters, which are the Hotel Philadelphian, 3900 Chestnut Street. The papers embrace discussions in both the ferrous and non-ferrous fields. The annual banquet is scheduled at the hotel for Wednesday evening, Oct. 22.

The program of papers is tentatively as follows:

"A Brief Discussion of the Manufacture of Steel for Arc Welding Electrodes," by C. W. Garret, Jones & Laughlin Steel Corp.

"High Speed Rotary Knitting Machine for Covering Electrical Conductors," by S. E. Brillhart, Western Electric Co.

"The Effects of Microstructure on the Galvanizing Characteristics of Steel," by R. W. Sandelin, Atlantic Steel Co.

"Diamond Dies for the High Speed Drawing of Copper Wire," by H. N. Padowicz, Western Electric Co.

"Stainless Wire for the Aircraft Industry," by J. K. Findley, Allegheny-Ludlum Steel Corp.

"Heat Treating," by H. M. Heyn, Surface Combustion Corp.

Paper by Kenneth Wyatt, Phelps Dodge Copper Products Corp. (Topic to be announced).

"Tune, Temperature and Size in the Heating of Steel Wire," by R. R. Tatnall, Wickwire Spencer Steel Co.

"Production of Commercial Bronze Screen Cloth Wire," by B. H. McGar, Chase Brass & Copper Co., Inc.

A. W. S. PROGRAM

(Continued from page 550)

"Development of Welding in Aircraft Industry, by M. Smith, Stout Skycraft Corp.

"Condenser Discharge Welding of Aluminum Alloys," by John W. Dawson, Raytheon Mfg. Co., and B. L. Wise, Federal Machine & Welder Co.

Structural Session

"Structural Welding," by Van Rensselaer P. Saxe, Consulting Engineer.

"Design of a Welded Bridge," by G. T. Horton, Chicago Bridge & Iron Co.

"Adapting Design and Construction Methods to Welding," by LaMotte Grover, Air Reduction Sales Co.

"Cleveland Liquefied Gas Storage Tanks," by J. O. Jackson, Pittsburgh-Des Moines Steel Co.

WEDNESDAY MORNING, OCT. 22

Research Session—Structural

"Tests of Miscellaneous Types of Welded Building Connections," by Bruce Johnston and G. R. Deits, Lehigh University.

"An Investigation of Welded Connections for Axially Loaded Angle Members," by G. J. Gibson and B. T. Wake, American Bridge Co.

Automotive and Aircraft Session

"Welding in Aircraft Construction and Maintenance," by A. K. Seemann, The Linde Air Products Co.

"Management Control of Design and Welding of Aircraft," by J. P. Dods, Summerill Tubing Co.

"Stored Energy Resistance Welding as Applied to Aircraft," by L. P. Wood, Curtiss-Wright Corp., Airplane Division.

WEDNESDAY AFTERNOON, OCT. 22

Resistance Welding Symposium

"Structural and Metallurgical Properties of Stored Energy Welds," by G. S. Mikhalapov and T. F. Falls, Taylor Winfield Corp.

"Pulsation Welding of Heavy Structures," by O. C. Frederick and R. P. McCants, General Electric Co.

"The Electrical Characteristics of Resistance Welders and Proximity Effect of Magnetic Work Materials," by J. H. Cooper, Taylor Winfield Corp.

"Power Control," by H. R. Crago, General Electric Co.

"Forging Welding," by L. M. Benkert, Progressive Welder Co.

"Spot Welding Control and Supervision," by J. R. Fetcher, E. G. Budd Mfg. Co.

Fundamental Research Session—Metallurgical

"The Effect of Plate Temperature and Variable Wind Velocities on Properties of Carbon Steel Metal Arc Welds," by John L. Miller, Firestone Tire & Rubber Co., and E. L. Koehler, Illinois Institute of Technology."

"Welding Aluminum Deoxidized and Aluminum-Containing Steels," by C. E. Sims and F. B. Dahle, Battelle Memorial Institute.

"Notch Sensitivity of Welds Under Repeated Loading," by H. L. Daasch, University of Vermont.

"The Tee Bend Test as a Method of Determining Weldability of Steel," by G. A. Ellinger, Bureau of Standards, A. G. Bissell, Bureau of Ships, Navy Dept., and M. L. Williams, Bureau of Standards.

National Defense Session

"Low Temperature Brazing in National Defense Projects," by Leo Edelson, Handy & Harman.

"Billet Cutting for Steel Forgings," by H. E. Rockefeller, The Linde Air Products Co.

"Austenitic Welding for Defense Equipment," by R. D. Thomas, Jr., Arcos Corp.

"Machine Cutting in National Defense Work," by R. F. Helmkamp and A. H. Yoch, Air Reduction Sales Co.

THURSDAY MORNING, OCT. 2

Resistance Welding Session

"The Effect of Condition of the Surface, on the Contact Resistance of Carbon Steel in Resistance Welding," by W. B. Kouwenhoven, Johns Hopkins University.

"Spot Welding Characteristics of Various Materials," by A. M. Unger, Pullman-Standard Car Mfg. Co.

"Electrical Measurement of Electrode Pressure and Travel During Spot Welding," by W. F. Hess and L. Daniel Runkle, Rensselaer Polytechnic Institute.

Machinery Session

"Flame Hardening Internal and External Round Surfaces," by Stephen Smith, Air Reduction Sales Co.

"Uses of Flame Hardening in Machine Tool Production," by A. L. Hartley, R. K. LeBlond Machine Tool Co.

"Welding of Cast Steel From Steel Foundryman's Viewpoint," by T. H. Booth, Walworth Co.

FRIDAY MORNING, OCT. 24

Piping and Pressure Vessels Session

"Flame Preheating and Stress-Relieving Arc Welded High Pressure Pipe Lines," by P. T. Onderdonk and Werner Peterson, Consolidated Edison Co. of New York.

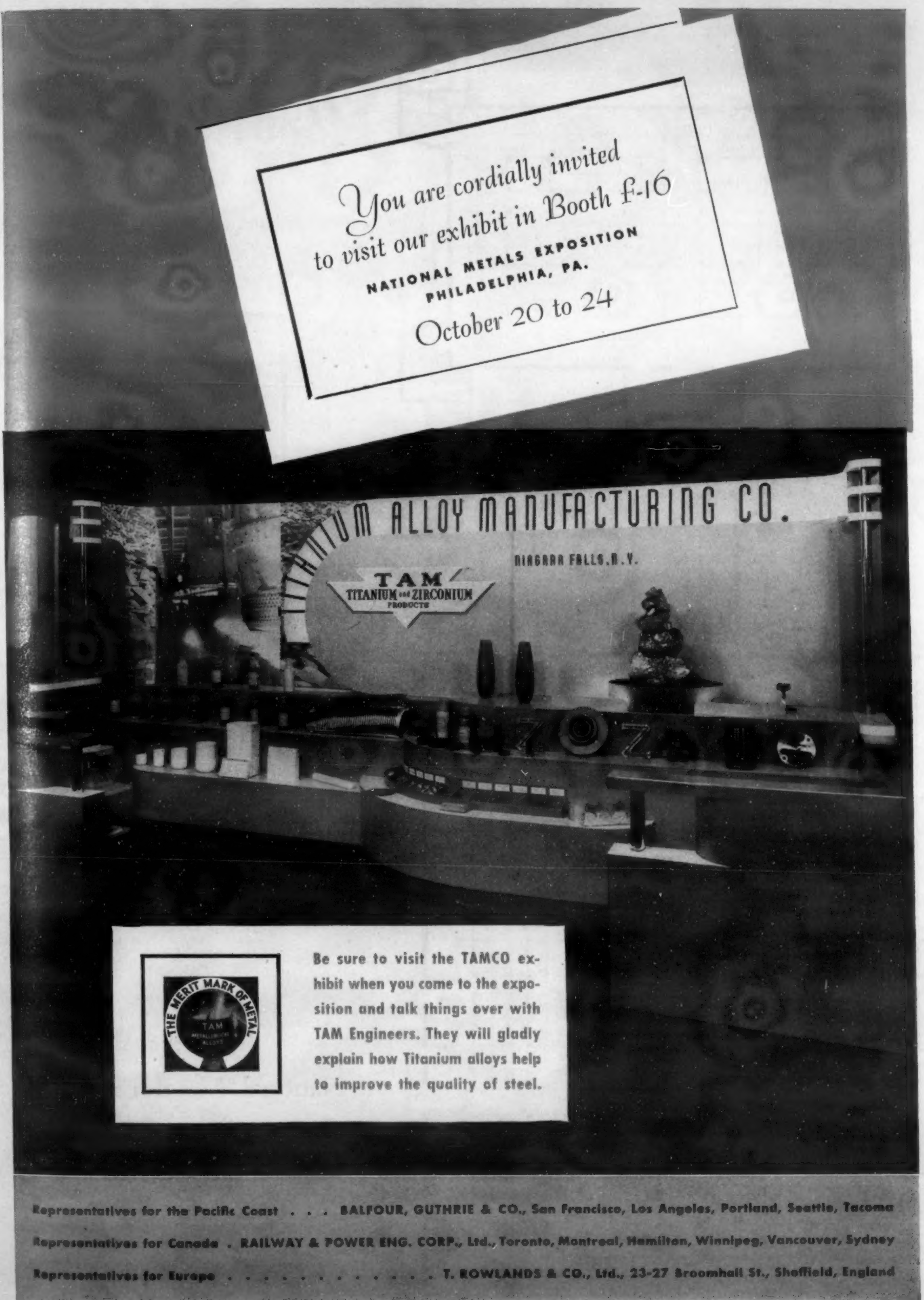
"Welding Pressure Vessels, Tanks and Heat Exchangers," by H. B. Schlosser, Edge Moor Iron Works.

"Technique of X-ray Examination of Heavy Drum Plate," by O. R. Carpenter, Babcock & Wilcox Co.

Session on Welding of High Alloy Steels

"Hardness Measurements on Rolling Steel That Contained Welds," by J. T. Phillips, Foster Wheeler Co.

"The Shotweld Process of Welding Stainless Steel," by Joseph Winlock and J. J. MacKinney, E. G. Budd Mfg. Co.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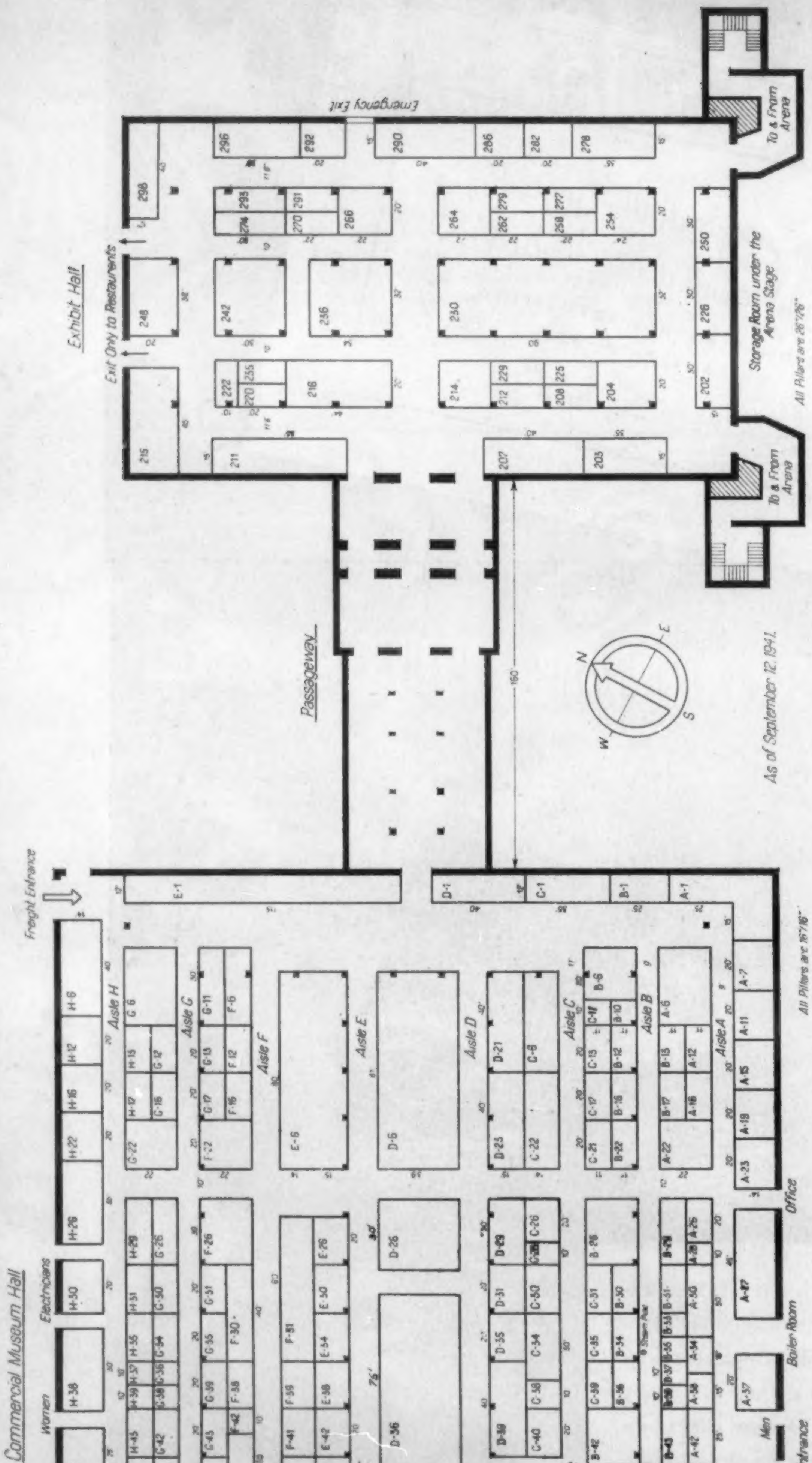

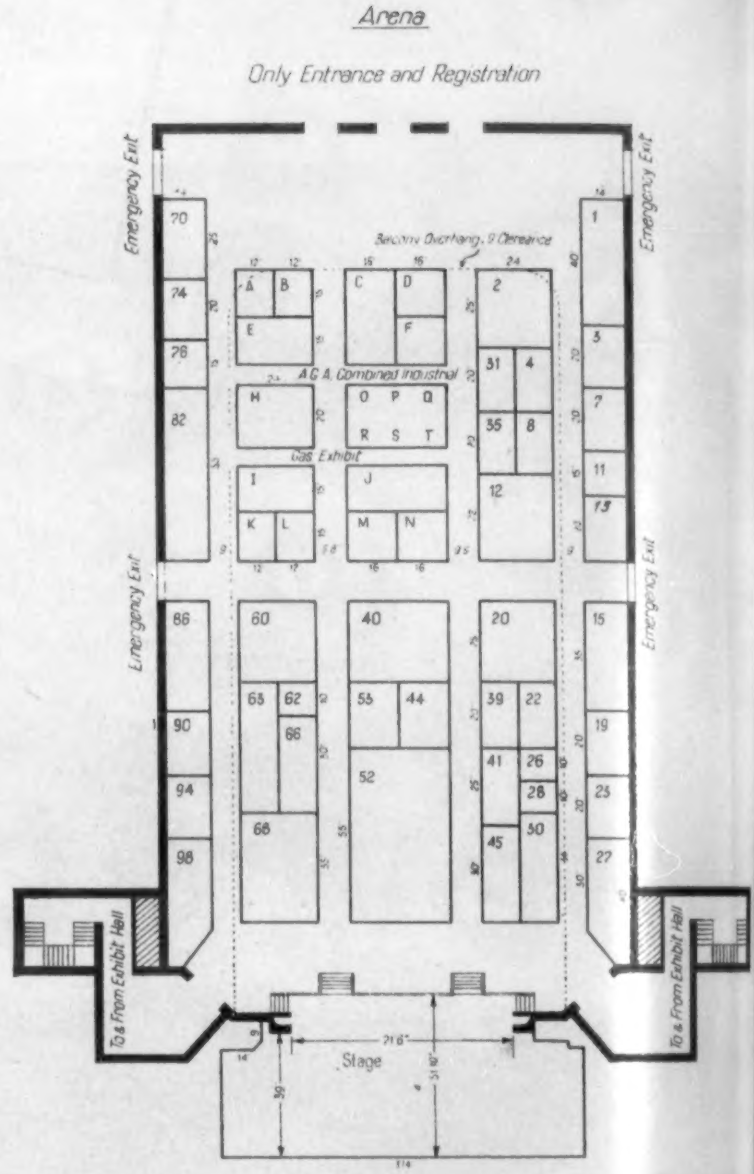

Floor Plan of the

National Metal Exposition

Philadelphia, Oct. 20 to 24, 1941

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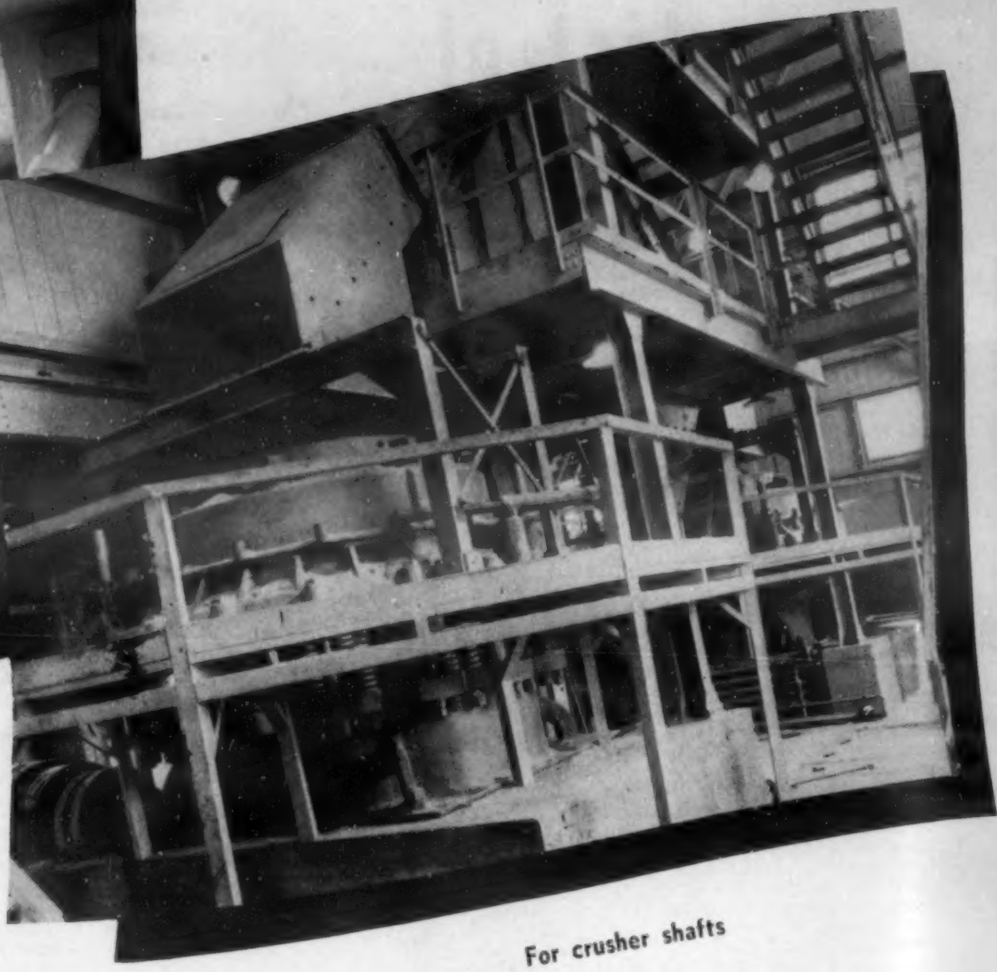
Jones & Laughlin Steel Corp., Pittsburgh.—Booth 216.

(Continued on page 562)

For Diesel crankshafts



For crusher shafts

MANGANESE VANADIUM

● Simple composition, simple heat treatment, high physical properties — all in one great forging steel.

● In light or heavy sections, only single normalize and temper—within the means of any heat treatment shop — develops an exceptional combination of high yield point, high ductility, high fatigue value, and unusual resistance to impact throughout a range that extends well below 0°F.

● In the normalized condition, the penetration of hardness is excellent, developing uniform hardness from the surface to the center of heavy forgings.

● Internal structure — characteristic of vanadium — is fine-grained and therefore of high toughness and impact resistant. Manganese Vanadium is also free scaling in forging. Machinability is excellent—the result of uniformity of hardness and microstructure.

● Many uses of this steel under severe service conditions are of long standing — such as reciprocating and revolving parts of locomotives, crusher shafting, shafts for Diesel engines, turbines and generators, piston rods for forging equipment, and various types of mining, oil refining and chemical machinery subjected to very cold climate or low temperature processes.

● Yet, with all these exceptional qualities, heat treatment *is* simple — no unusual sensitivity at heat treating temperatures — no unusual modifications in the simplest shop practice—an ideal steel where high prop-

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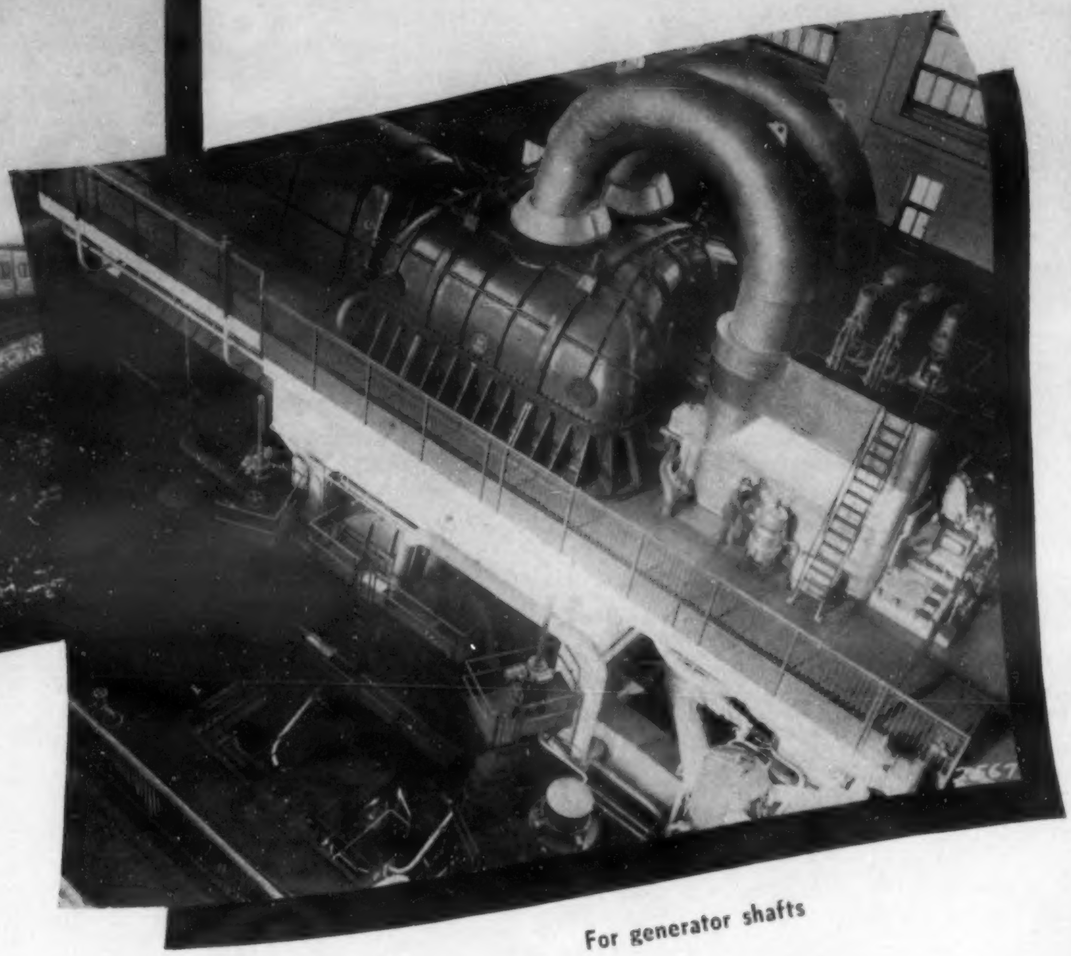
For various locomotive forgings



For generator shafts

erties must be developed easily and accurately with a minimum of heat treating facilities.

● The New York Central specified Manganese Vanadium for main and side rods on 50 Mohawk type locomotives purchased last year and for 15 more now on order. And for light sections, the Pilliod Company uses Manganese Vanadium for all modernized Baker valve motion parts. Average results of many tests on these applications are shown in the table following.

MANGANESE VANADIUM STEEL

	Main Rods	Side Rods	Baker Valve Motion Parts: Radius Arms	Baker Valve Motion Parts: Bell Cranks
Y. P. lbs. sq. in.	**76,110**	**75,100**	**81,000**	**78,500**
Tens. Strength	**103,410**	**103,100**	**106,500**	**99,400**
Elong., % in 2"	**26.9**	**28.2**	**26.5**	**27.5**
Red. Area, %	**63.0**	**60.1**	**64.1**	**65.9**

DIUM

FERRO ALLOYS

(Continued from page 559)

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C. M. Kemp Mfg. Co., Baltimore.
The Kent Co., Inc., Rome, N. Y.—Booth C-49.
Andrew King, Narberth, Pa.—Booth B-31.
Krouse Testing Machine Co., Columbus, O.—Booth 212.
Kuhlman Electric Co., Bay City, Mich.—Booth E-50.

Latrobe Electric Steel Co., Latrobe, Pa.—Booth 15.
Lebanon Steel Foundry, Lebanon, Pa.—Booth 298.
Leeds & Northrup Co., Philadelphia.—Booth 20.
Lepel High Frequency Laboratories, Inc., New York.—Booth 229.
Lewis Machine Co., Cleveland.—Booth C-58.
L'Hommedieu & Sons Co., Chas. F., Chicago.—Booth E-44.
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Manganese Steel Forge Co., Philadelphia.—Booth D-21.
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Marburg Brothers, Inc., New York—Booth 262.
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National Time & Signal Corp., Detroit.—Booth B-63.
National Tube Co., Pittsburgh.—Booth, Stage.
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Metallurgical Engineering Digest

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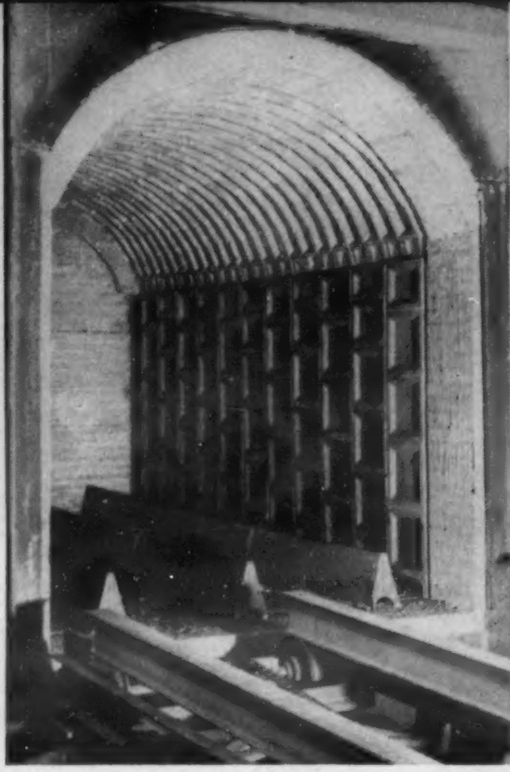

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3 MAKE SURE YOUR EQUIPMENT IS IN GOOD CONDITION

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REFRACTORY DIVISION, PERTH AMBOY, N. J.

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Blast Furnace Practice, Smelting, Direct Reduction and Electrorefining. Open-Hearth, Bessemer, Electric-Furnace Melting Practice and Equipment. Melting and Manufacture of Non-Ferrous Metals and Alloys. Soaking Pits and other Steel-Mill and Non-Ferrous-Mill Heating Furnaces. Steel and Non-Ferrous Rolling, Wire Mill and Heavy Forging Practice. Foundry Practice, Furnaces, Equipment and Materials. Manufacture of Die Castings.

Gates and Risers

THE TECHNIQUE OF GATES AND RISERS ("Aus der Praxis der Anschnittechnik") R. LEHMANN. *Giesserei*, Vol. 28, May 2, 1941, pp. 197-204. Practical

The determination of arrangement and size of gates, risers and strainer gates in a mold is discussed, and a few practical pointers are given. The strainer gate section should be slightly larger than the pouring gate and at least twice as large as the ingate.

The ingate diameter is twice as large as the upper width of the slag catcher, and the lower width of the slag catcher is equal to the upper width of the ingate (if only one is required). The depth of the strainer gate is equal to the width of the ingate arch, and the thickness of the latter (for one ingate) is equal to ⅔ of the upper width of the slag catcher.

The section of the entrance is determined from A = weight of piece/flow velocity × filling time × unit weight (spec. gr.). The flow velocity should be 2-3 ft./sec., an average of 2.5 ft./sec. to be conveniently used for calculation.

The filling time depends on the design of the casting; for 1 dm.^{3} of heavy pieces with thick walls 1-3 sec., for average pieces 3-5 sec. may be expected. The flow velocity in the ingate can be determined from $V = \sqrt{2 \times 0.85 \times g \times h}$ for light metal, $\sqrt{2 \times 0.75 \times g \times h}$ for cast iron, and $\sqrt{2 \times 0.70 \times g \times h}$ for steel and heavy metals. Directions are given in diagrams for the best arrangement of ingates, gates, risers, and their functions explained in detail. Ha (1)

Foundry Sand

"SOME FUNDAMENTAL ASPECTS OF FOUNDRY SAND." E. J. ASH & ERIK O. LISSELL (Univ. of Mich.) *Foundry*, Vol. 69, July 1941, pp. 60-61, 118-119; Aug. 1941, pp. 60, 130-131. Investigation.

The apparent deficiencies of the A. F. A. method for preparing the standard compression test for sand are explored through the study of factors influencing the ramming process.

The primary factors of any sand are its shape, size, distribution of grains, amount and type of clay, water content and grain surface condition. Ottawa sand was used as typical of round sand grains and Ohio crushed silica sand as the angular sand.

Sand and water were mixed in a "wingmaster." Specimens were rammed on an A. F. A. standard rammer. The moisture content was determined on the sand in a rammed specimen.

The permeability number was calculated from data based on the time required for 2 liters of air to flow through the standard specimen under measured pressure. Permeability was influenced by the actual amount of voids present; the actual surface area of the grains; the shape of the voids; and the surface condition of the sand grains.

The chief difference between British and American specimens is the degree of compression. The British specimen is compressed to one or more standard densities before testing, while the A. F. A. specimen is rammed by allowing a fixed amount of kinetic energy to be converted into compression work.

The density of a rammed sand specimen is controlled by the frictional resistance between grains. This in turn can be traced to: size and shape of grains; surface condition; grain distribution; and water content.

The density increases with the grain size. Water added to a clay-free sand will increase the frictional resistance of the grains —that is, the dry apparent density decreases and intergranular space increases.

Dry apparent density or dry weight of the same sand is constant and independent of water content above 2% moisture. The apparent density, on the other hand, increases as a hyperbolic function.

True density was determined by a density bottle having a volume of 50 cc. of water at 15°C. The values obtained were, for Ottawa sand, 2.65; for No. 7 angular, 2.64.

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Dry voids are constant and independent of the moisture above 2%.

The ramming of British specimens is based on an "index of ramming." This index of ramming = (dry apparent density × 100/true density)—42. The term in parentheses represents the % volume by grains, or 100 minus dry voids. Therefore, the formula may be written: Index of ramming = 100 — dry voids — 42.

Flowability is constant and independent of moisture above 2%. Flowability tests at 225°F. showed values of 92-97 for round grains.

Using the A. F. A. method of preparing sand grains, the following results were obtained: Round sand grains are more flowable than angular grains. Round grains are more dense when rammed than angular grains.

Angular grains have greater intergranular space when rammed. Angular grains have higher permeability than round ones.

Between 2 and 12%, water variation has no effect on intergranular void volume, on dry permeability and on flowability. In the low moisture range (0.5-2.5% for round and 0.5-4% for angular grains) green permeability exceeds dry permeability values. VSP (1)

1a. Ferrous

Hydrogen in Steel

"CONTROL OF HYDROGEN IN STEEL." HENRY D. HIBBARD. *Steel*, Vol. 108, June 16, 1941, p. 69-70, 103-104. Practical discussion.

A method is proposed for eliminating hydrogen from molten steel by varying the boil. The most important source of hydrogen in steel is probably the water vapor in the gases in the melting chamber. The only apparent means of expelling hydrogen from the metal is the boil of the bath.

It is very likely that the carbon monoxide of the boil has the power to carry off with it some of the other gases, including hydrogen, in the metal. A strong boil may be more effective. The temperature during the working period should not be too high, as otherwise it lessens the vigor of the boil and increases the solubility of the metal for gases.

Carbon and, particularly, manganese may also have some solvent power for hydrogen. Prolonging the boil proportionately eliminates these elements also and thus favors expulsion of hydrogen.

To eliminate hydrogen, the boil should be varied in volume and perhaps in vigor according to the amount of humidity in the air when the metal is being melted. The following table shows a tentative program for making rimming steel with 0.10% C and 0.35% Mn, and gives the proper carbon content in the bath metal when tapped in varying atmospheric conditions.

Air temp., °F.	Saturation of air in %			
	Below 30	30-60	60-80	80-100
Below 32	0.08	0.08	0.07	0.06
32-50	0.08	0.07	0.06	0.06
50-70	0.07	0.06	0.05	0.05
70-100	0.06	0.05	0.04	0.04

The necessary carbon to give 0.10% in the finished steel will be gained from additions. If this proposed procedure does not prevent trouble from hydrogen, it may be necessary to limit the amount of water vapor that enters the melting chamber by blowing producers with air instead of steam and by drying the air entering the furnace for combustion. MS (1a)

Ingot Molds for Killed Steels

"ROLE OF THE INGOT MOLD IN CONTROL OF SEMI-FINISHED SURFACE ON KILLED STEELS." HENRY J. FORSYTH (Republic Steel Corp.) *Blast Furnace & Steel Plant*, Vol. 29, June 1941, pp. 609-617. Investigation.

Studies were made in a plant that produces all grades of open-hearth killed steels in 100- and 200-ton basic furnaces. Twenty x 20 in. Gathmann molds, producing a 7200-lb. ingot, were used for experiment and all production tonnages.

Mold coating is a basic yet often neglected operation affecting the surface of killed steels. Properly applied coatings will so effectively reduce the number of tears and seams on billet surface that they are indispensable to producers of billets who must pickle billets and remove all defects. Elimination of scabiness, frequently claimed to be the only advantage derived from coating molds, is a distinctly secondary benefit.

Liquid tar and powdered pitch are the most effective coatings for killed steels. It was demonstrated that an average of 1.2

hrs. chipping per billet ton could be saved by using properly coated molds. Where used for steels containing less than 0.25% C, mold coatings produced the greatest benefit by reducing the number and depth of large surface defects.

"Mold action" on coarse-grained steels and corner cracking on certain critical grades, often attributed to mold coatings, were found to occur with equal severity on ingots from coated and uncoated molds used for the same heat. The mold temperature when tar coatings are applied must be controlled and should be the highest that will give a smooth, even coating. In most cases, excellent results are obtained when the molds are between 300° to 450° F.

Pitch has a lower volatility than tar and will generally produce a slightly better surface, but it must not be used in excess. Mold temperatures for pitch must be above 200° F.

Mold age exerts a profound influence on the billet surface of higher carbon steels because of progressive "fire-checking" of the inner walls. The amount of chipping increased from an average of 150 ft. per ingot produced from molds 5 pours in service to 365 ft. per ingot produced from molds 115 pours in service. Actual production records for the same grade of steel showed only a moderate increase in average scarfing hrs. per ton during the first 60 pours in service, a sharp increase between 60 and 80 pours, and then a gradual increase through the remaining life of mold.

Experiments with coated and uncoated molds having different service lives showed that surface defects on billets from uncoated molds decreased with mold age. New uncoated molds produced more defects than old coated molds.

Observation and experiment showed that new molds, whether coated or uncoated, have a marked tendency to produce corner cracks, and will do so during the first 10 pours in service. It is very important that molds less than 10 pours in service are not used for any grade of steel susceptible to corner cracks, especially when coarse-grained. Large butt cracks can also be traced to new molds.

Tests with different soaking times showed that scarfing hrs. per ton decreased with increasing soaking time, because of progressive elimination of small seams and scabs by increased scaling of ingots in soaking pits. This indicates that good soaking practice can reduce detrimental effects of poor mold conditions, and that ingots from properly-coated and good molds should produce good billet surface with normal or slightly subnormal soaking. MS (1a)

Die Heating in Wire-Drawing

HEATING OF WIRE AND DIE IN WIRE DRAWING ("Erwärmung von Draht und Düse beim Kaltziehen") A. EICHINGER & W. LUEG. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch. Düsseldorf*, Vol. 23, No. 2, 1941, pp. 21-30. Research.

Heat is produced in wire drawing by the plastic deformation in the wire and by the friction between the wire and die. Experiments are described to determine the friction coefficient and the temperature distribution in the wire; a steel wire with 0.05%C and a patented steel wire of 0.59%C were used in the experiment.

The friction coefficient depends largely on the pressure, which influences the viscosity of the lubricant, and on temperature, and to a certain extent also on the velocity of the wire in the die.

The mechanical energy consumed in drawing was found, in the soft steel wire, to be equivalent to the heat produced. In the patented wire, a latent heat remaining after drawing of about 10% was found, both in the patented and in the annealed state. The formulas for the calculation of temperature, temperature equalization and the velocity of the latter are derived. Ha (1a)

High Quality Pig Iron

"MANUFACTURE OF HIGH QUALITY, LOW COST STEEL; BASIC OPEN-HEARTH IRON." PAUL J. MCKIMM. *Steel*, Vol. 108, June 23, 1941, pp. 62, 64-66. Practical discussion.

The quality of pig iron depends more on the iron maker than on the type of charge. The practice of using virgin ores with 50-56% Fe and pushing the blast-furnace beyond its practical operating limits for production in order to meet economical cost may result in iron of questionable quality. An alternative to obtain good yield, low cost, and more desirable iron is to use scrap, when the price permits, and other cheapeners.

High-quality iron has been produced consistently for years with burden containing 16% open-hearth slag and 35% scrap, with


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45% during some periods. Results were a saving of 400 lbs. coke and 450 lbs. limestone over straight ore, cinder, mill scale and slag; the yield was much greater than furnace rating; smooth and constant movement in the furnaces was obtained; and uniform composition of iron resulted.

The iron contained consistently 0.90-1.15% Si, with the last ladle in the cast containing 0.85% Si. The iron is charged directly into the open-hearth furnace from the ladle without mixer or mixer-cars.

The burden can contain 16-20% open-hearth slag without causing ill effects, even though phosphorus increases to 0.35%. Many blast-furnace operators contend that higher manganese (2-2.50%) in the pig is beneficial. It actually has no apparent effect on steel quality because residual manganese will usually be the same, depending on open-hearth procedure.

Sulphur is reduced more economically in the blast-furnace than in the open-hearth furnace. Sulphur can be considerably higher than generally specified, as there is always sufficient manganese to maintain manganese sulphide with no excess sulphur to form iron sulphide. Tests conducted with steel for extra-deep-drawing cold strip where ladle sulphur was 3 times as high as the maximum permissible showed no ill effects in processing or in testing.

Irregular furnace operation will produce poor iron. Irrespective of charge, chemically or physically, the furnace can be operated so as to maintain uniform temperatures, smooth movement of the stock and normal reactions, thus producing quality iron. Much of the condemnation of iron quality by open-hearth operators is unjustified, as they can often overcome the difficulty encountered by proper manipulation of the charge. MS (1a)

Ferro-manganese from Low Grade Ore

THE MANGANESE REQUIREMENTS OF THE STEEL INDUSTRY ("Manganbehovet inom Staal industrien") HELGE LÖFQUIST. *Jernkontorets Annaler,* Vol. 125, No. 4, 1941, pp. 147-183. Survey and research.

The most important manganese alloys used in the steel industry, with geographical distribution of manganese ores are reviewed. The author has developed a method for the production of ferro-manganese from low grade ores.

In this process the ore is first smelted in a blast furnace, to produce spiegeleisen. As soon as it is tapped, the spiegeleisen is treated in a mixer with an oxidizing slag high in FeO and low in SiO_2, and iron sulphide in the form of pyrite, pyrrhotite, or synthetic FeS. The following reactions take place:

$$Mn + FeO \rightleftarrows MnO + Fe$$
$$Mn + FeS \rightleftarrows MnS + Fe$$

A low melting slag (melting point below 2350°F.) is obtained, containing 50-60% Mn, 1-3% Fe, and 10-18% S. In about 10 min. the reaction is completed and the slag is tapped. Additions are calculated to leave 3 to 5% Mn in the iron.

No silicious material is added to the charge. The sulphide-oxide slag is roasted and reduced with coal in a blast furnace or an electric furnace, giving a ferro-manganese practically free from phosphorus.

The pig iron obtained is treated with iron ore (preferably high in manganese) in a basic open hearth furnace, where a steel with 0.3-0.4% Mn and a slag with 15-30% Fe and 30-40% Mn are produced. This slag is again used as oxidizing agent in the slagging of the spiegeleisen.

Thus a manganese recovery of nearly 100% is obtained. The iron in the spiegeleisen and in the slagging agents is obtained in the form of pig iron which is converted into steel.

In slagging the spiegeleisen it has also been found possible to use certain by-products, such as the iron hydrate obtained in the precipitation of iron from spent pickling liquors. Nickel sulphide may also be used as a source of sulphur, giving a pig iron containing nickel. BHS (1a)

1b. Non-Ferrous

Foundry Practice for Magnesium

"MAGNESIUM SAND CASTINGS." N. M. BRISKIN (Ford Motor Co.) *Iron Age,* Vol. 148, July 10, 1941, pp. 47-53. Practical review.

Magnesium alloys are usually melted in oil- or gas-fired crucible furnaces. The ideal furnace for magnesium is the high-frequency induction furnace; the eddy currents produced in the metal by this method cause perfect mixing of the alloy and prevent segregation.

Open pot melting is used mainly for remelting scrap and for small permanent mold castings. The crucible process consists of melting a prepared alloy in a

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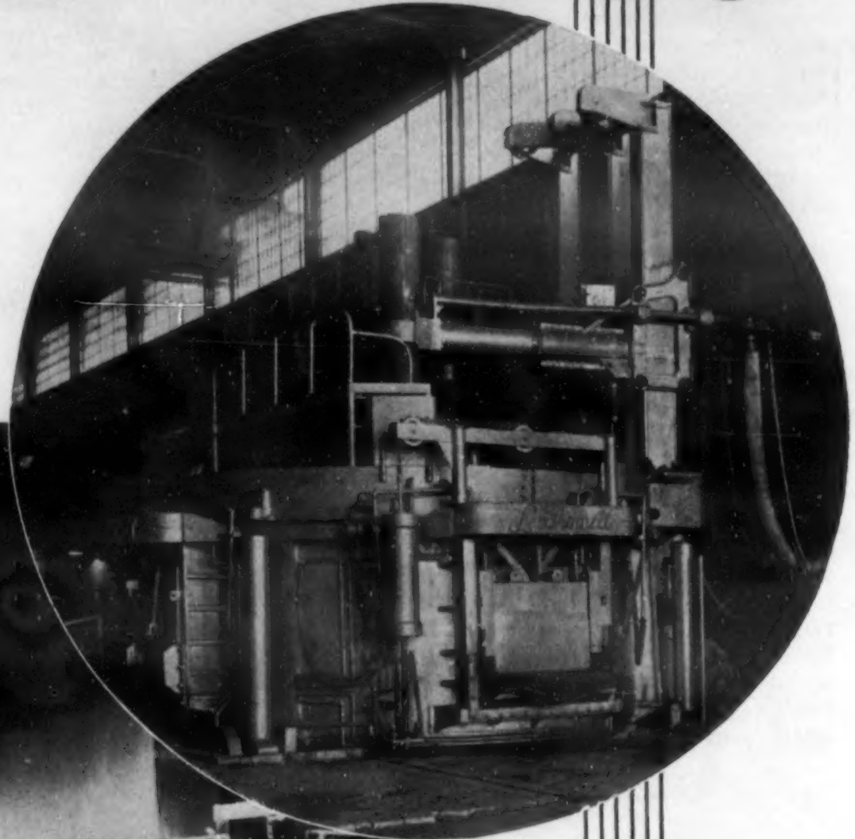

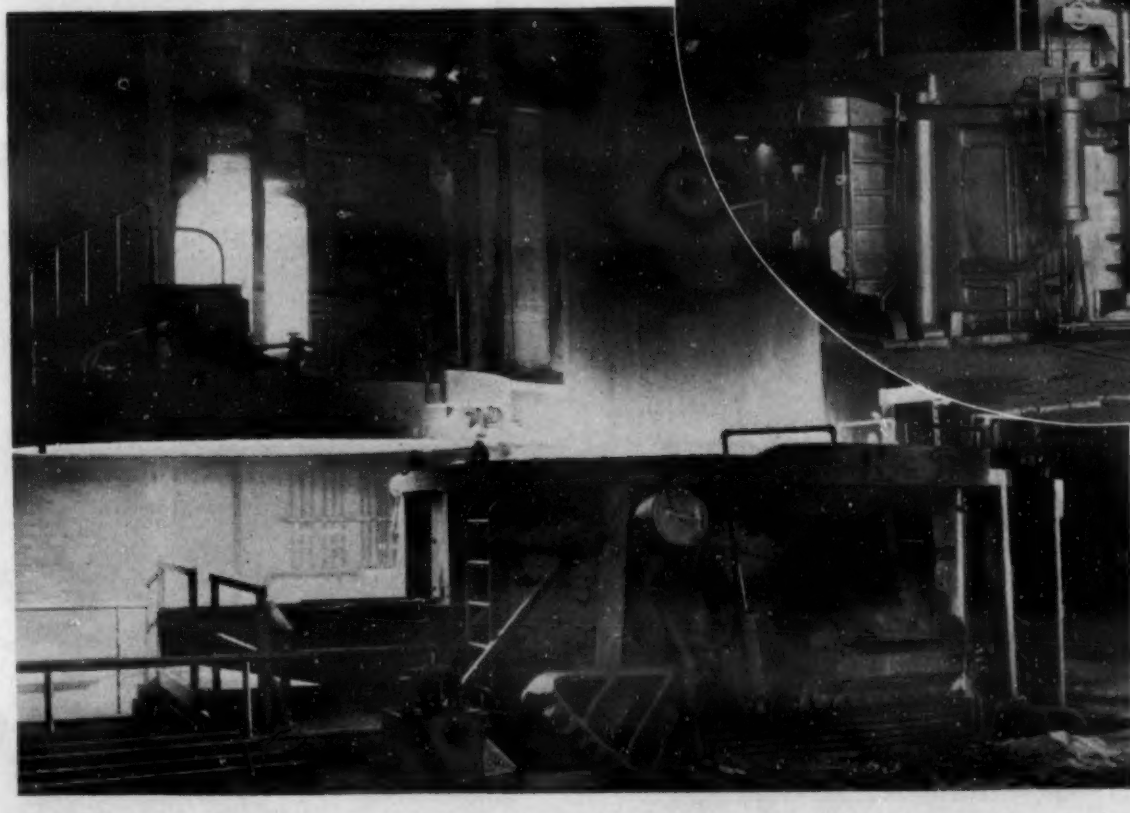

The 50-ton top charge LECTROMELT furnace pictured here is now in operation at the Copperweld Steel Company, Warren, Ohio, on alloy steel production. The upper view shows the furnace in normal operating position. The lower view shows the furnace with roof rotated to permit quick charging with drop bottom bucket. Two furnaces of similar size are now under construction in our shops.

Both top charge type and door charge LECTROMELT furnaces are available. LECTROMELT furnaces are built in standard sizes ranging from 100 tons down to 25 pounds capacity. Two 75-ton machine—door change furnaces are in operation at a large Eastern steel plant. The top charge type of furnace results in savings in man hours, power, electrodes, and refractories. Write for details.

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steel crucible, and then carrying the entire crucible to the mold for pouring; this eliminates excessive oxidation.

The last process is used universally for sand castings. The flux is dusted on the bottom and side walls of the crucible and over the charge. Stirring with an L-shaped rod brings the metal in contact with the flux, which dissolves all entrained oxides and nitrides and sinks to the bottom of the crucible. Dross is then removed and more flux is added, to cover the surface.

The total amount of flux used is about 1% of the weight of charge. Common practice in pouring is to skim off flux and dust on a mixture of sulphur and boric acid. Sulphur protects the mixture from oxygen in the air, and boric acid prevents moisture from reacting with the metal.

Calcium is the best deoxidizer, and is added to the extent of 0.5%. In melting, the metal is superheated to about 450°F. above the melting point to obtain fine grain structure. For S.A.E. 50, fine grain structure is obtained on superheating to 1600°F. and cooling to pouring temperature, which varies from 1420° to 1520°F. depending on the size of the casting and wall thickness.

To avoid water explosions, a mixture of sulphur and boric acid (2% of each) is added to green sand. The greatest defect found in magnesium castings is shrinkage, and, therefore, ample gates and risers should be provided.

Another form of microscopic porosity is caused by turbulence or unquiet filling of mold. This type of defect usually shows up near an improperly designed in-gate, near a sharp corner. Micro-shrinkage in small castings consisting chiefly of thin, flat walls not over $\frac{1}{4}$ to $\frac{3}{8}$ in. thick, and can be detected by x-ray.

Oxides may be kept out by placing screens, traps and steel wool filters in the down-sprue. Oxide formation due to burning after entering the mold can be eliminated by control of addition agents, by the use of calcium before pouring, and by making certain that any flame on the burning metal in the crucible is extinguished before pouring, by using sulphur and boric acid.

Cast iron chills are useful in heavy sections to rapidly solidify metal. This eliminates external and micro-shrinkage by freezing the grains of pure magnesium and grain boundary constituents at the same time. Large chills have vents drilled through them. VSP (1b)

Casting Nickel Alloy Valve Parts

"Moulding Steam Valve Lids for Marine Service." Frank Hudson. *Foundry Trade J.*, Vol. 65, July 17, 1941, pp. 39-41. Descriptive.

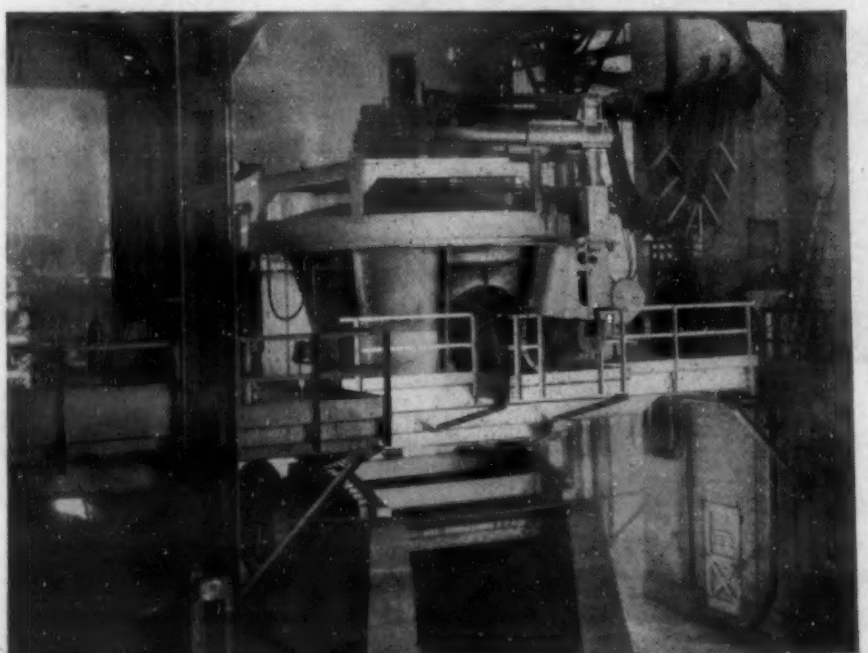
For many years, cast non-ferrous alloys have been widely used aboard ship for lids in boiler valves. The disc in a marine valve is a casting attached to the operating spindle, and forms the valve component controlling the flow of steam between boiler and turbine.

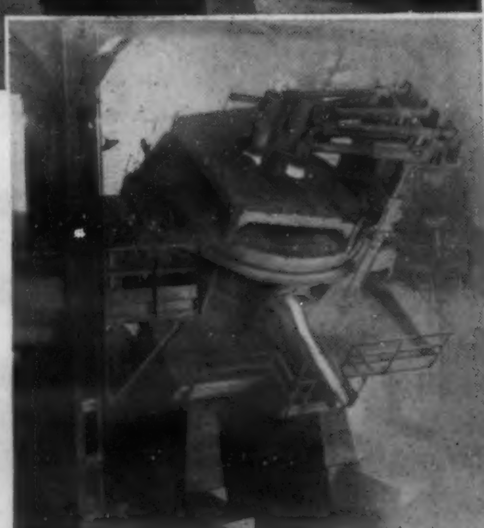
The alloy employed should possess good elevated temperature properties in order to withstand the effects of superheated steam, and castings made from it must be perfectly sound in every way. The necessary service conditions are being met by the use of nickel alloys of one kind or another. Their melting is not unduly difficult, providing a good furnace is available and full use is made of correct melting technique.

Pouring temperature for all the nickel alloys used for valve discs is high, between 2650 and 2800° F., according to the composition employed. Unlike gunmetal, however, there is a wide latitude in this direction, and the relation between pouring temperature and casting section is not critical.

Metal should be poured as hot as possible. The temperature range required is outside the scope of the most suitable foundry type of immersion pyrometer, but a very good guide can be obtained by testing the metal with a $\frac{1}{4}$-in. mild steel bar. If the molten metal just melts the end of this bar, bringing it to a point, it can be assumed that the temperature is around 2725° to 2825° F. If the bar does not quite melt, but evolves sparks, then the temperature is in the lower range of 2640° to 2725° F.

No metal of the types mentioned should be poured lower than 2640° F. The best results are obtained by the use of dry sand molds, but green sand can be utilized for small castings if necessary. The methods used for molding valve discs do not readily lend themselves to the production of "cast-on" test-bars, and the use of separately cast bars should be adopted. AIK (1b)





Processing 2 and Fabrication

FORGING, FORMING, MACHINING HEAT TREATMENT, WELDING, FINISHING

Drop and Hammer Forging, Drawing, Extruding, Stamping and Machining. Age-Hardening, Annealing, Carburizing, Hardening, Malleableizing, Nitriding, Surface-Hardening and Tempering. Heating Furnaces, Refractories, Fuels and Auxiliaries. Welding, Flame-Cutting, Hardfacing, Brazing, Soldering and Riveting, Cleaning, Pickling, Electroplating, Galvanizing, Metallizing, Coloring and Non-Metallic Finishing.

Electroplating Aluminum on Steel

"Progress in Research and Control."
Light Metals, Vol. 4, July 1941. Review.

If the process were commercially feasible, the electroplating of aluminum on iron and steel would offer decided advantages over hot dipping methods or methods involving heat and pressure. One important advantage would be the minimizing or complete avoidance of the formation of the brittle alloy layers between the coating and basis metal. Another advantage would be the possibility of offering protection to finished products.

Aluminum has been deposited from aqueous solutions, but the process is fraught with such difficulties that apparently the best hope for the electroplating of metals with aluminum lies in the use of other plating media. Various non-aqueous solutions such as aluminum nitrate in liquid ammonia, aluminum sulphate in fuming sulphuric acid, and others have been investigated, but the chief difficulty is the same as that experienced with aqueous solutions, *i.e.* reaction of the nascent aluminum with the solvent.

Organic Electrolytes

Organic solvents might be expected to yield more satisfactory results, but even in this case there is danger of the aluminum reacting with the electrolyte. It must be remembered that in the electro-deposition of aluminum, the protective oxide film is not present on the aluminum surface, hence the aluminum is highly reactive. For example, 0.01% water in ethyl alcohol will vigorously attack a clean aluminum surface. While aluminum can be deposited from a solution of aluminum bromide in ethyl bromide, rapid solution of the aluminum occurs. The behavior with a solution of aluminum iodide or bromide in pyridine is similar.

Attempts to deposit aluminum from halides in polar organic compounds have been unsuccessful. However, insufficient work has been done to prove the use of such compounds unfeasible.

Considerable work has been done using alumino-organic compounds of the Grignard or Friedel-Crafts type. A mixture of aluminum ethyl and diethyl iodides dissolved in dry ether yielded an electroplate, using a current density of 0.02 amps./cm.^{2} at 40 volts. However, solutions containing a Friedel-Crafts type of aluminum organic complex have proved more successful.

One typical solution of this nature was made up of 20 gm. $AlCl_3$, 20 gm. $AlBr_3$ and 40 cc. ethyl bromide in 120 cc. of a mixture of xylene and benzene. Current density was 1.55 amps./dm.^{2} at 20°C. The solution which gave optimum results contained 20 gm. each of $AlCl_3$ and $AlBr_3$, 4 gm. Al dissolved in a mixture of 80 cc. benzene, 40 cc. xylene and 40 cc. ethyl bromide. The cathode efficiency was above 75% and the anode efficiency was above 100%. The corrosion protection of the aluminum deposits on steel was equal to an equivalent weight of zinc, and the coating could be anodized and dyed, indicating good uniformity.

The bath prepared as indicated above separates into 2 layers; the upper one, consisting mostly of benzene and xylene, acts as a protective medium and keeps out air and moisture. The vessel is covered with a tight-fitting lid to keep out moisture, and a tube is provided to allow for the escape of gases. The electrolyte must be maintained between 20° and 25°C. The current density varies from 10 to 20 amps./ft.^{2}, the higher density being suitable for use with water-cooled anodes.

Precautions must be taken to prevent the inflammable electrolyte from catching fire and to prevent electrolysis of the upper layer. The vent should incorporate a method of recovering bromine.

Salt Bath Electrolytes

Although much work has been done in investigating fused salt baths for electrodeposition, the results have not been particularly gratifying. The choice of suitable salts is naturally very limited; for example, the temperature must be kept below the melting point of aluminum. It has been found very difficult to control the variables

and hence insure reproducible conditions.

A molten mixture (1:1) of aluminum chloride and sodium chloride has been used as electrolyte with generally unsatisfactory results. The deposits were often dark, coarse-grained, and non-adherent. Other mixtures of the same two salts were used with varying success.

In one case, a reasonably good deposit was obtained, but the composition of the bath changed in a very short time and yielded poor deposits. A current density of 0.2-.4 amps./dm.^{2} was used at a temperature of 125°-130°C. The bath was tolerant of aluminum oxide, 1% Al_2O_3 having no appreciable effect on the electrolysis when using 2 $AlCl_3$: 1 NaCl.

The structure of the deposit seemed to depend mainly on the current density, the concentration of the aluminum chloride and the duration of the electrolysis. Temperature seems to have little effect, and the coating thickness (0.0005-0.001 mm.) is independent of the duration of the plating.

Some platings quite resistant to corrosion were made from 3:1 and 2:1 molar proportions of $AlCl_3$-NaCl. The high corrosion resistance can probably be ascribed to the extreme purity of the deposited metal, a feature of the electrolytic methods in general. Satisfactory coatings 0.08 mm. thick were obtained with some of the above mixtures when working at 200°C. and using a current density of 1 amp./dm.^{2}

In surveying the results of workers who have used fused salt mixtures, best results seems to have been obtained in the presence of a high concentration of the aluminum salt, and the use of low current densities and potentials. It has been suggested that the superposition of 10% a.c. on the d.c. current favors formation of smooth deposits. This may be caused by an improvement in the aluminum ion concentration gradient at the cathode. Stirring the bath should perhaps function similarly.

In summary it may be said that some of the methods for the electrodeposition of aluminum look promising, and that further work is unquestionably justified. AUS (2)

Welder Qualification

"Standard Qualification Procedure. Section 1. Manual Arc and Gas Welding of Ferrous Materials." *Welding J.*, N. Y., Vol. 20, July 1941, pp. 448-465. Standardization report.

The use of fundamentally proper methods of welding by trained welders using a qualified procedure gives assurance of high quality in the weld. Under a fixed procedure for welding the only factors under the control of the welder are adequate fusion with the base metal and freedom from slag inclusions in the weld.

It is the belief of the reporting committee that the first step in welding must be the adoption of a procedure of welding in which all essential variables are fixed within definite limits. The procedure for welding should then be investigated to determine whether it will produce welds with the desired physical properties. The tests required for a welding operator are included in the investigation of a welding procedure, because there have been many instances wherein failure to obtain results has been attribued to the inability of the operator when the difficulty actually lay in the fundamentals of the procedure.

Having established that a given procedure is satisfactory, comparatively simple tests, intended primarily to determine the ability of an indiivdual to make a sound weld, may then be used for the qualification of welding operators. The types of tests and purposes for procedure qualification are listed as: (a) For *Groove Welds*, (1) reduced-section tension test (for tensile strength); (2) free-bend test (for ductility); (3) root-bend test (for soundness); (4) face-bend test (for soundness); (5) side-bend test (for soundness). (b) For *Fillet Welds*, (1) longitudinal or transverse shear test (for shear strength); (2) free-bend test (for ductility); (3) fillet-weld-soundness test (for soundness).

The positions of test welds are classified as (1) flat, (2) horizontal, (3) vertical, and (4) overhead, and are further defined for various limiting angles by means of illustration sketches. The number of test welds required and the number, type and preparation of test specimens are given for various plate and pipe thicknesses. Methods of testing the specimens are discussed in detail. The design of the welds in the different test specimens, methods of removing test specimens and the specifications for jigs, etc., for making the tests are illustrated by detailed sketches and drawings.

The test results required are that (a) the tensile strength shall be not less than 100% of the minimum of the specified tensile range of the base material used; (b) the elongation (in free-bend test) shall be not less than 30% for stress-relieved welds nor less than 25% for non-stress-relieved welds; (c) any specimen in which a crack or other open defect is present in the convex surface after the bending, exceeding

⅛ in. measured in any direction, shall be considered as having failed (cracks occurring on the corners of the specimen during testing shall not be considered); (d) for the longitudinal shear test specimen the shearing strength of the welds in lbs./in.[2] shall be not less than ⅔ of the minimum of the specified tensile range of the base material, and for the transverse shear test specimen the shearing strength of the welds in lbs./in.[2] shall be not less than ⅞ of the minimum of the specified tensile range of the base material. (These shear values are applicable only to low-carbon, non-alloy steels).

The test results specified are not likely to be attained with the metal arc process when using bare or lightly coated electrodes. For such processes it is recommended that the governing Code adopt the following requirements for the test results: The specimen shall be considered as having passed if (1) no crack or other open defect exceeding ⅛ in. measured in any direction is present in the weld metal or between the weld and base material after the bending, or (2) the specimen has cracked or fractured and the fractured surface shows complete penetration through the entire thickness of the weld, and absence of slag inclusions and porosity to the extent that there are no gas pockets or slag inclusions exceeding 1/16 in. in the greatest dimension, and that the sum of the greatest dimension of all such defects in any square inch of weld metal area does not exceed ⅜ in.

A retest may be made provided there is evidence that the operator has had further training or practice. An operator who has qualified for metal arc welding under any given procedure specification is not required to requalify for that procedure unless he has done no metal arc welding for a period of 3 mos. or more. WB (2)

Contour Machining

"Contour Machining." H. J. Chamberland (Continental Machines, Inc.) *Modern Machine Shop*, Vol. 14, Sept. 1941, pp. 112-116. Descriptive.

Among the more modern methods that are receiving special attention for efficient defense production is "contour" machining—sawing metals to rough or finished contour through the use of a special table, work holding fixtures, positioners, etc.

The most important function of contour machining lies in its use for relieving older types of machine tools of heavy cutting operations requiring slow speeds and feeds. Contour machining is not necessarily limited to shaping by sawing to a layout line and then file-finishing; the process can be employed to remove the bulk of the metal, with the parts finished by the usual procedure.

In one typical application—the machining of 4 "flats" on a 350-lb. diesel wrist-pin made of 0.45% C steel and measuring 12 x 18 in.—the machining time of 8 hrs. per pin by conventional methods was reduced to 2½ hrs. by contour sawing with a 1-in. saw, and about 50 lbs. of useful material was saved per pin.

In another instance oil-hardened steel stitching dies are contour-sawed very close to shape from 1¾ in. material at the rate of 32 parts in 23½ hrs., or about 45 mm. per part.

In still another case, contour-machining of dies is reported to have more than compensated its labor cost in material saved. The dies are of 2-in. tool steel, and the machining time is a fraction of that required by other methods.

One aircraft plant making a number of special micrometer frames, varying in size from 7 in. to 16 in. of ⅜-⅝ in. thick chromium-molybdenum steel, is able to saw each frame to shape in 45 min. (2)

"Perfect" Nickel Plating

"Factors in the Production of Perfect Nickel Plating." S. Wernick. *J. Electrodepositors' Tech. Soc.*, Vol. 16, 1940, pp. 35-44. Practical.

A good nickel deposit should possess the following qualities: good adhesion to base metal; nonporosity; freedom from pits, inclusions, or blisters; ductility; and uniformity.

Alkali cleaners are discussed in general. Cleaners made up with hard water may leave precipitates on the work. Sodium hexameta-phosphate (0.8 oz./gal.) is used to prevent formation of a precipitate, and it may also be used in a still rinse, which latter is followed by a running rinse.

Anodic etching of steel is recommended to secure good adhesion. The addition of a wetting agent, such as iso-propyl naphthalene sulphonic acid ester (0.3 to 0.7 oz./1000 gal.), will prevent pitting in a nickel bath.

Rough deposits result from particles in the bath which may come from dust which originates in the polishing room, ventilating fans, generator brushes, etc. The amount of particles given off by anodes is reduced by the use of carburized anodes. These form a carbon film when in use which helps to retain the anode particles. Racks and racking materials are also a source of bath contamination. AB (2)

Electro-Tinning vs. Hot Dipping

"Tin Electrodeposition and Its Field in Industry." S. Baier & W. H. Tait. *J. Electrodepositors' Tech. Soc.*, Vol. 16, 1940, pp. 45-54. Descriptive review.

The advantages of electrodepositing tin over hot-dipping are discussed. Tin may be electrodeposited in any thickness whereas coatings obtained by hot-dipping lie between 0.0001 and 0.001 in. in thickness.

The electrodeposited coatings are more uniform in thickness than hot-dipped coatings. By electrodeposition, tin may be applied to any common base metal; hot-dipping can not be applied to lead or lead alloys or to soft soldered articles because of the low melting point of the tin-lead alloy. Zinc cannot be hot-dipped because it contaminates the molten tin, and to a smaller extent brass gives the same trouble.

On some objects it is advantageous to use hot-dipping to seal seams and crevices and then to use electrodeposition to produce a thicker coating. Tin can be more readily applied to articles of intricate shape by electrodeposition than by hot-dipping.

In electro-tinning the interior of large vessels, the vessel itself is made the plating tank. For this purpose the stannate bath is preferable to the acid bath, as in the latter bath tin anodes produce a slime that falls to the bottom and results in a rough coating.

Refrigerator parts and dairy equipment are plated with 0.0005 to 0.001 in. of tin. Food processing equipment is plated with 0.002 to 0.012 in. of tin.

In addition to its uses as a corrosion-resistant coating, the following special uses of electro-tinning are discussed: anti-friction coating for pistons and piston rings; pretinning before soldering; production of water tight joints. AB (2)

2a. Ferrous

Fatigue Strength of Welded Joints

"Fatigue Tests of Welded Joints in Structural Steel Plates. W. M. Wilson, W. H. Bruckner, J. V. Coombe & R. A. Wilde. *Univ. Illinois Bull.*, Vol. 38, No. 27, Series No. 327, 1941. Research.

Fatigue tests of plain plates and plates with butt and fillet welds in structural carbon and low-alloy steels were carried out at Univ. of Illinois in cooperation with the Public Roads Administration, Federal Works Agency, The Chicago Bridge and Iron Co. and the Bureau of Ships, U. S. Navy.

The tests described in the bulletin were planned to determine (1) fatigue strength of butt welds in 7/8 in. carbon steel plates of structural grade, (2) the relative fatigue strength of welded and riveted joints in low-alloy plates of structural grade, (3) the effect of frequent periods of rest upon the fatigue strength of butt welds in carbon-steel plates of structural grade, and (4) the effect of transverse fillet welds upon the fatigue strength of plates. The fatigue tests were supplemented with static tests and metallurgical studies.

Three ranges of min. to max. stress were used for fatigue tests, (1) from a given tensile stress to an equal compressive stress, (2) from zero stress to some given tensile stress, (3) from a given tensile stress to a tensile stress one-half as great. The specimens, tested in the large 200,000-lb. fatigue testing machines are 4 ft. long and 5 in. wide in the gage length; smaller specimens 2 ft. 8 in. long with a 3 in. width were tested in smaller, 50,000-lb. machines.

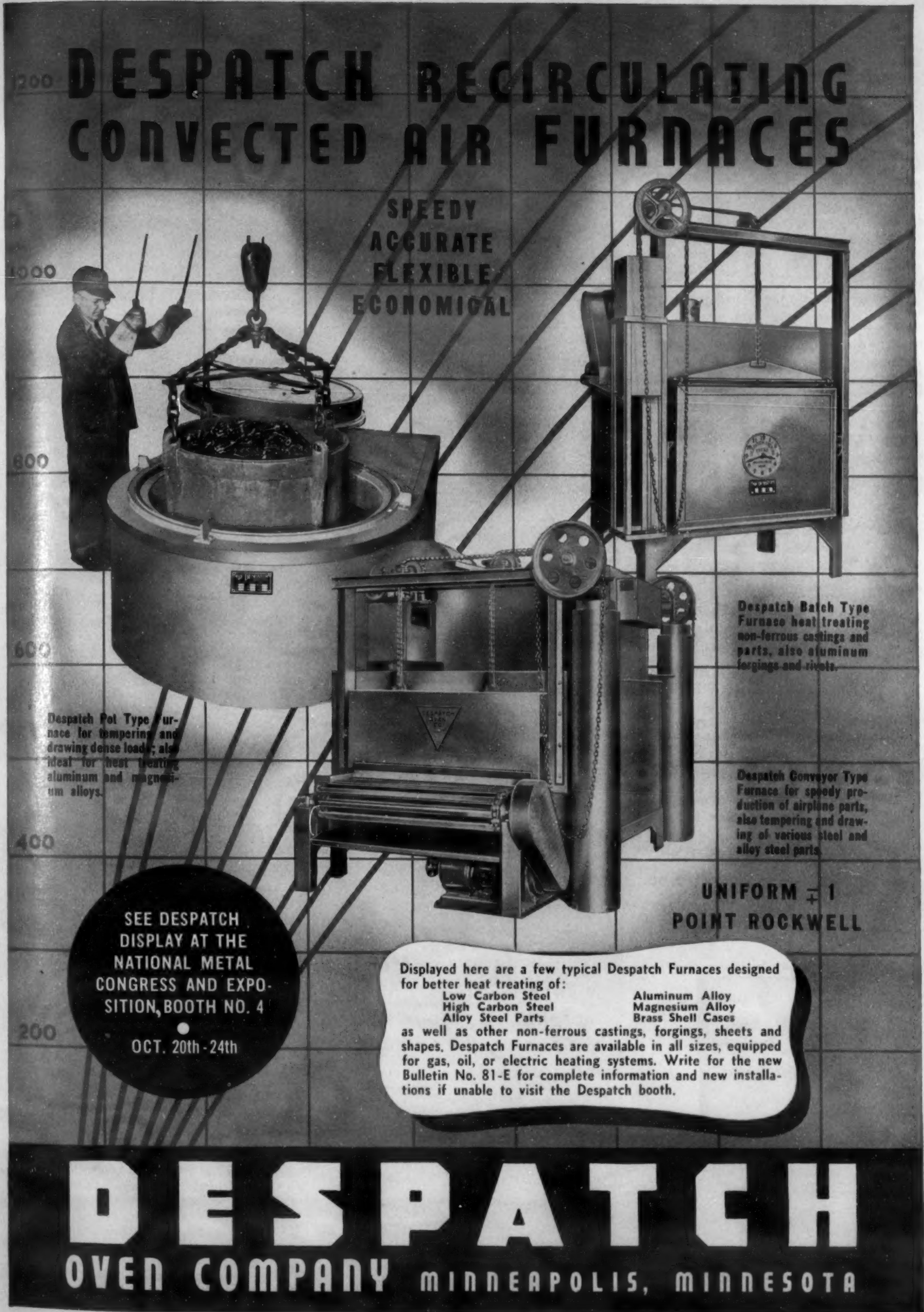
The first series of tests were made on 7/8 in. thick plain carbon steel plates rolled from the same ingot with carbon contents of 0.28 and 0.23% average for 2 plates from which all specimens were taken. Control specimens tested statically gave respectively 63,500 and 59,100 lbs/in.^{2} average for the 2 plates.

The specimens were tested to determine fatigue strength in (a) as-welded condition, (b) as-welded and stress-relieved for 1 hr. at 1200°F. and furnace cooled, and (c) weld beads planed flush and ground flush with base plate both in as-welded and as-welded and stress-relieved condition. Control fatigue tests were carried out with plain plates and with plain plates after removing mill scale and polishing the surface.

Effects of Processing

The results of fatigue tests reported in the bulletin were somewhat erratic due to the large number of surface and internal stress raisers usually present in the welds, which have a considerable effect in reducing the fatigue strength. The radiographic rating of defects in welds was compared with the results of fatigue tests, indications were that no direct comparisons could be made. High and low radiographic ratings were both associated with occasionally low or high fatigue strengths.

A survey of the profile of the reinforcement was made and compared with results of fatigue tests with the opinion that there was some evidence that it may be possible to distinguish between an unusually good



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and a bad type of reinforcement.

Stress relief appears to have had no significant effect on fatigue strength of the specimens tested. Where the reinforcement was machined off the fatigue strength was considerably greater than for the as-welded specimens and for as-welded and stress-relieved specimens.

However the specimens in which the reinforcement was ground off with a portable grinder, as would be done in the field, behaved erratically and did not attain fatigue strengths as high as the machined, weld-bead-off condition. A macrograph of a fatigue specimen with weld reinforcement ground off shows that the fatigue failure has been induced by the stress raisers at the bottom of the coarse grinding marks left on the specimen by the portable grinder.

Other Factors

Static tests were made on fatigue specimens of plain plates that did not fail after 2 to 4 million cycles. They had high strength and good ductility even when subjected to repeated tensile stress exceeding the original yield point.

Metallurgical studies indicated that fatigue cracks usually started at internal stress raisers in the weld metal when the specimens were tested with the reinforcement removed flush with the base plate. When the reinforcement was not removed, the specimens generally failed at the edge of the weld reinforcement which was a more effective stress raiser than occasional defects in the welds.

The heat-affected zone with maximum hardness values of 200 Vickers or less was apparently ineffective and did not reduce fatigue strength or cause failure in this region when the reinforcing bead was removed.

A series of test data is reported for a comparison of fatigue strengths of riveted and welded manganese-vanadium steel with 0.16% C. The welded plates had a slightly higher fatigue strength than riveted plates. All of the welds were tested in the as-welded condition and failed at the edge of the welds. Higher fatigue strength could probably have been attained had the reinforcing been removed flush with the base plate.

Another series of tests was made with periods of rest during the fatigue tests to simulate service conditions in the life of a bridge structure. There was no significant effect on the fatigue strength from rest periods of 0, 5, 30 min. for the specimens, all of which were tested on a stress cycle below the elastic limit.

Another series of tests was made to determine the effect of transverse fillet welds on fatigue strength. These specimens consisted of plain plates (Type 1) of carbon steel and manganese-vanadium steel and single-T (Type II), and double-T or cruciform (Type III) welded joints. The fatigue strength of Type I and II specimens was significantly higher for the alloy steel and the fatigue strength of both steels decreased in the order I, II, III, indicating that geometry of the joint determines the life of such welds in fatigue service.

Flush Removal of Reinforcement

One of the most important conclusions from the tests of ⅞ in. thick carbon steel plates is that machining off of the weld bead flush with the base plate gives the specimen practically the same fatigue strength as the unwelded plate with mill scale on. This type of joint preparation is impractical for field welds but can be applied to shop welds to give greater safety in fatigue service at slightly increased cost over the as-welded condition.

The difference in behavior of the as-welded joints in static and fatigue tests is significant in that failures occur entirely outside of the welded area in static tests while fatigue failures are almost invariably at the edge of the added weld metal that forms a crown or reinforcement (which the welding profession has heretofore considered necessary).

On the basis of the fatigue tests reported this added metal has a significant effect in reducing fatigue strength. The welding profession could therefore profitably work toward producing a weld joint with a weld beadflush with the base plate in the as-welded condition. WB (2a)

Welding Tubular Aircraft Structures

"PRACTICAL ARC WELDING OF TUBULAR STRUCTURES." F. H. STEVENSON (Vega Airplane Co.) *Welding J., N. Y.*, Vol. 20, July 1941, pp. 466-470. Practical.

The prime requisites for successful arc welding of tubular structures used in the aircraft industry are close fit-up of parts to be joined, welding in a properly constructed jig that will hold the parts in position (but not so rigid as to prevent contraction), and proper welding sequence. Good results from a welding department are assured when management designs for arc welding, establishes a procedure that will give the results expected, and qualifies the welding operators to follow that procedure.

Some parts require no pre-heat or stress relief while others are pre-heated to 250°-350° F. and stress relieved at 500°-600° F. Welding of forgings, which are relatively

massive, to tubular members requires more careful preparation; for welding, the S.A.E. X4130 steel used for gussets must have the carbon on the low side of the specification, otherwise the welds may develop cracks. An inspector passes on the welding of each unit and every tenth unit made is X-rayed.

It has been found that a good grade of mild steel electrode is most satisfactory for welding the X4130 grade of steel, but where subsequent heat treatment is required alloy electrodes are employed.

The arc welding process is used rather than the oxyacetylene torch because of the more rapid construction possible with the former. For example, one welder with the torch required 9 hrs. to complete the structure while 2 units were welded in 8 hrs. using the arc. Thickness of material, however, limits the application of the arc to wall thickness above 0.058 in.; below this limit, the use of the torch is mandatory. WB (2a)

Malleableizing Cupola White Iron

"Graphitization of Cementite in Cupola White Iron." N. A. Ziegler, W. L. Meinhart & A. J. Deacon. *Am. Foundrymen's Assoc.*, Preprint No. 41-15, May 1941.

A study is made of the expansion of cupola white iron, during the malleableizing process, by means of a dilatometer. The iron selected for the experiments had a composition as follows: Total carbon, 3.16% T.C.; 2.98 C.C.; 0.91 Si; 0.47 Mn; 0.092 S; and 0.17 P.

The information obtained on the growth of this white iron during the malleableizing cycle is correlated with graphitization phenomena not only by means of dilatometer experiments but also through micro-examination and chemical analysis. The work of previous authors on initial growth and the temperatures at which it occurs is confirmed.

In these experiments, only the excess cementite and limited amounts of carbon held in solution by austenite are graphitized during the first stage graphitization. The most efficient method of carrying the reduction of pealite to ferrite and graphite during the second stage graphitization is to reduce the temperature within the eutectoid range in steps, since no graphitization occurs in that temperature range in reasonably short time periods. The first and second stage graphitization phenomena can be represented by isothermal "S" curves. CMS (2a)

Electrolytic Descaling

"Developments in Connection with the Bullard-Dunn Pickling Process." John Kronsbein. *J. Electrodepositors' Tech. Soc.*, Vol. 16, 1940, pp. 55-60. Practical.

The Bullard-Dunn process consists in descaling steel articles by making them cathodic at 60-80 amps./ft.^{2} in a hot dilute sulphuric acid solution, containing 1 g./l. of tin sulfate. Wherever scale is removed, tin is deposited.

The deposit does not become very thick because after the steel is once covered, the additional deposit becomes spongy. The tin coating protects the cleaned areas from further attack by the acid, and the high hydrogen overvoltage on tin reduces the current density on the plated areas.

The hydrogen embrittlement resulting from the Bullard-Dunn process is only temporary. Measurements of the transverse breaking loads of steel bars showed that the embrittlement disappeared after 1 to 14 days at room temperature, or after 2 hrs. treatment at 212° F.

Although the tin coating deposited on the cleaned surface is thin, it is sufficient to prevent corrosion during storage. Accelerated and atmospheric tests were made of painted steel specimens, of which some had not been pretreated and others had been pretreated by (1) shot-blasting and Parkerizing, (2) Bullard-Dunn-cleaned (tin not removed). The specimens prepared by the latter process showed more corrosion resistance than the others. AB (2a)

Die Typing for Forging Dies

"Die Typing to Speed Production." W. F. Sherman (Staff) *Iron Age*, Vol. 148, July 31, 1941, pp. 35-37, 96; Aug. 7, 1941, pp. 46-51. Practical.

Die typing has proved economical where more than 10 sets of duplicate dies are needed at a time. Die typing may be compared with die hubbing. The chief difference is that hubbing is done cold, while typing is done hot, and a different kind of die steel is used. The process starts with a slightly oversize "cut" die (master-master die), which is used to forge blocks of die steel; these in turn are used for forging sets of production dies.

Die typing eliminates machine work on production die impressions. Its attendant advantages are reduction in time required to produce finished set of dies; forged die structure has improved life, attributable to hot working of die material during forging operation on die; and dies have been produced as small inserts in larger die retaining blocks. However, typing cannot replace die sinking since the master impression must be cut out of solid metal.

The master-master die is cut according to conventional practice, but with the die block only slightly larger than the die impression to be made in it, since all dies are made up as inserts. In forming these dies, only sufficient metal is placed in the depression in the lower retainer block to insure complete filling.

Before inserts are mounted, they are hardened. A typical analysis of die steel used for typing dies is: 0.4-0.44% C; 0.50-0.60 Mn; 0.60-0.75 Cr; 1.50-1.75 Ni; 0.10-0.20 Si; 0.04 or less S and P. For severe usage, die blocks have been made from straight 3.5% Cr steel.

Forging temperature of die steel for typing is 2250° F. Die insert billets should be cleaned before typing begins. The billet is protected by a sheet metal cap while being heated, and the gas flame must be sulphur-free.

The best protection of surface finish in typing of dies is the use of 0.001 in. nickel plating. The desired hardness of the finished die is attained by heat treating after typing.

Practice calls for hardness of 418-477 Brinell on dies for light and 321-387 Brinell for heavy forgings. Stamping dies, depending on the job, have hardness of 52-60 Rockwell C.

Practical size limitations were found to be 2 ft. by 3 ft. Small dies are typed in presses of 400-6,000 tons, but for larger dies, especially for forging and upsetting steam hammers of 2500-5000 tons are used.

Typed dies used for producing forgings give evidence that they can produce 200% more forgings than conventional machined dies; the average increase in production is 25-100%. A master-master die is capable of producing 300-600 master dies. The die insert holder can be used for 10 successive inserts. VSP (2a)

Flame Grooving

"Manual and Machine Flame Grooving." E. V. David (Air Reduction Sales Co.) *Welding J., N. Y.*, Vol. 20, July 1941, pp. 417-428. Descriptive.

Flame grooving of carbon steels with less than 0.35% C is not detrimental, and is permitted by the great majority of codes and specifications for low and mild carbon steels, in recognition of the fact that edge properties are equal or superior to planed, milled or otherwise mechanically prepared grooves. Where welding is done on the grooved edges, the edge zone becomes part of the weld and is obliterated.

In flame grooving of alloy or higher C steels, pre-heating is applied to prevent cracking of edges due to the hard, brittle structures resulting from the cutting of initially cold steel. A preheat of 500°-600° F. is usually sufficient for carbon steels, but some steels may be preheated to 1000° F. for cutting and grooving.

The advantages cited for flame grooving are the high speeds of 1 to 4 linear ft./min., and with an accuracy of 1/16 in. for manual and 1/32 in. for machine methods. Other advantages are less noise, which provides easier working conditions in the shop, and the portability of the equipment, which makes possible setting up in yard, field or shop. Economy of the method is shown by a comparison with maintenance of mechanical cutting equipment.

The controlling factors are listed and discussed; oxygen pressure, tip size and angle of tip are important. To deepen a groove only a simple manipulation of the tip to increase the angle of impingement is necessary, or the oxygen pressure may be increased with the same tip setting. For starting grooves in certain types of work "waster" plates are used.

Many illustrations are given in sketches and photographs of the many applications of flame grooving for preparing defective areas for re-welding, for removing root beads, and for sealing weld deposition. The preparation of plate edges for welding is an important use of flame gouging and many of the various types of grooves that can be made by this method are illustrated. WB (2a)

Dross Formation in Galvanizing

"Reducing Dross Formation in Hot Dip Galvanizing." R. J. Kepfer & L. D. Enbank (E. I. du Pont de Nemours & Co., Grasselli Chem. Dept.) *Steel*, Vol. 108, June 2, 1941, pp. 84, 95-96. Investigation.

The difference in the amount of dross produced using zinc ammonium chloride as a pre-dip compared with hydrochloric acid was determined.


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It takes a big ground crew to keep planes aloft. Houghton, who started in business a generation before man dared to fly, is proud today to be part of that ground crew.
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Pieces, 3 x 4 in., of S.A.E. 1020 hot-rolled black sheets were pickled in 8.5% sulphuric acid at 160° F. for 4 min., dipped into running tap water 3 times, immersed in pre-flux solution for 2 min., and stood in room atmospheres for 3, 10 and 50 min. Pre-dips containing zinc ammonium chloride were kept at 160° F., and hydrochloric acid solutions, at room temperature.

After standing, the pieces were galvanized by immersing for 45 sec. in No. 1 grade zinc held at 860° F., and shaking them quickly after withdrawal to remove excess zinc. The zinc was contained in a small glass beaker partially immersed in a much larger zinc bath and was covered with a thin layer of top flux maintained by occasional additions of zinc ammonium chloride and glycerine.

The zinc was analyzed for iron and then 16 sheets were immersed in it and the iron analysis repeated. This was repeated 3 more times and the 4 different amounts of iron picked up by the zinc bath were averaged. The zinc coating obtained averaged 1.2 oz./ft.^{2} of surface covered.

Results showed that 35-70% more iron was dissolved by the zinc bath when 3% hydrochloric acid was used as a pre-dip than when using zinc ammonium chloride solutions. There was no increase in the amount of iron dissolved by the galvanizing bath as the time of standing between pre-dipping and galvanizing was increased. There was little difference when using 20, 35 and 40% zinc ammonium chloride solutions.

An average dross savings of about 11 lbs. per 5000 sq. ft. of surface galvanized was obtained when using a zinc ammonium chloride pre-dip; or stated another way, for each ton of zinc used for galvanizing, a minimum of 55-60 lbs. more dross was formed when using a hydrochloric acid dip.
MS (2a)

Metal-Sprayed Stainless Steel

"How to Spray Stainless Steel." C. F. Benner (Gen. Elec. Co.) *Iron Age*, Vol. 148, July 17, 1941, pp. 56-59. Practical.

The metallizing process is particularly useful in reclaiming hydraulic rams, rolls, etc. Spraying of stainless steel is essentially the same as spraying plain carbon steel. The process as a whole consists of: (1) preparation of base; (2) spraying of metal; and (3) finishing.

The bond between the base metal and sprayed metal is strictly mechanical, and, therefore, depends on proper roughening of base metal, having the base metal absolutely clean, and finely atomizing the sprayed metal particles.

It has been the practice for hydraulic rams to undercut and thread or groove the surface thereby increasing the mechanical strength of bond. With pitted rams, the surface is first turned down.

The amount of undercut depends on the size of the shaft and the thickness of the coat needed. Metallizing Engineering Co. has determined the following minimum coat thicknesses, as dependent on shaft diameter:

Diameter	*Minimum Coating Thickness*
1 in. or under	0.010 in. on radius
1 in. to 2 in.	0.015 in. on radius
2 in. to 3 in.	0.020 in. on radius
3 in. to 4 in.	0.025 in. on radius
4 in. to 5 in.	0.030 in. on radius
5 in. to 6 in.	0.035 in. on radius
6 in. or over	0.040 in. on radius

After undercutting the ram is grooved or threaded. Roughening with a special tool and cleaning free from oil or grease then follow.

A standard metallizing gun is used and No. 11 B. & S. stainless steel wire of the following analysis: 0.060% C, 0.57% Mn, 20.00% Cr and 9.75% Ni.

If the piece is 2 in. or under, it should be turned during spraying at an r.p.m. that will give a surface speed of about 35 surface ft./min. and carriage feed set at 1/8 in./rev. If the piece is over 2 in. in diam., it should be turned at an r.p.m. giving a surface speed of about 50 surface ft./min. and carriage feed of 1/6 in./rev.

In places where much metal has to be removed to eliminate unsoundness, it is more economical to build these areas up with plain carbon steel and follow with stainless, so that about 0.040 in. of the latter will be deposited. VSP (2a)

Heat Treating High Speed Steel

"Surface Carbon Chemistry and Grain Size of 18-4-1 High Speed Steel." W. A. Schlegel (Carpenter Steel Co.) *Trans. Am. Soc. Metals*, Vol. 29, Sept. 1941, pp. 541-605; discussion 606-622. Unusually comprehensive research.

The relationship of time, temperature and furnace atmosphere to surface decarburization and carburization of 18-4-1 high speed steel during its heat treatment is investigated. The data apply, to a limited degree, to several special methods of heat treatment. A study of grain size as related

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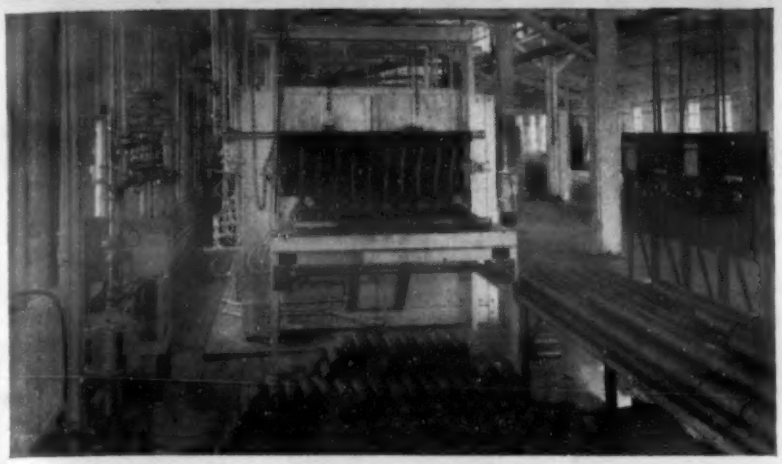

Some E F Installations for National Defense

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This EF gas-fired special atmosphere pusher type shell heat treating installation, consisting of a tube type hardening furnace, an automatic oil quenching equipment and a draw furnace, hardens shells uniformly, scale-free, continuously and automatically—one of several sizes and types we have designed and built for this purpose.

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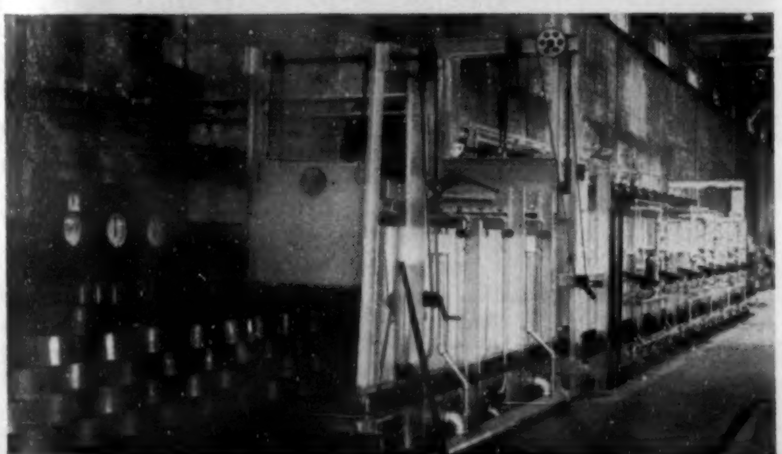
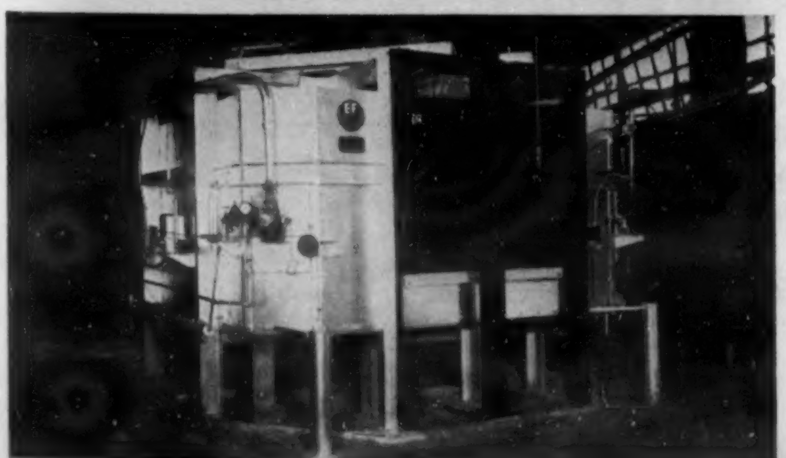
These EF furnaces produce the uniformly hard, wear-resisting surfaces required on aircraft engine cylinders and other aircraft engine parts. Designed for mass production, these EF nitriding furnaces are mounted on rails, in rows and in such a manner as to permit practically continuous operation. Built in various sizes and types.



Annealing Brass for Cartridge Cases

Coiled copper alloy sheet at the rate of 10,000 lbs. per hour, is annealed in this EF gas-fired continuous roller hearth type furnace. Equipped with circulating fans and spray quench for uniform heating and cooling, this equipment handles coils up to 24" in diameter and 26" in width—continuously. No trays are used—100% net material.



Heat Treating Alloy Steel Forgings

An EF oil fired continuous rotary hearth type furnace—one of a number we built for heating alloy steel forgings for drawing, hardening and normalizing at temperatures ranging from 1000 to 1800° F. This installation has capacity for heating to 1800° F., 1000 lbs. of steel per hour. Can also be furnished in larger or smaller sizes.

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to surface carbon reactions and as affected by heat treatment time, temperature and atmosphere was also made.

Contrary to the generally-held belief that the commonly-used reducing atmospheres for high-speed-steel hardening are prone to *decarburize* such steels, it is demonstrated that during normal heat treating with a freely moving atmosphere some *carburization* may be expected.

Under the microscope this carburized zone may easily be misinterpreted as a decarburized region. Also, the carbon concentration in these areas is high enough to prevent the austenite from completely transforming into martensite during the normal quench. This retained austenite can easily persist after a single draw, with a consequent soft skin.

Repeated temperings succeeded in breaking down this retained austenite and *increasing* the surface hardness. *Soft skin, commonly blamed on decarburization, may thus actually be caused by carburization during hardening.*

All types of atmospheres containing less than 16% CO produced surface carburization in normal heat treating procedures. Atmospheres with more than 16% CO frequently produced decarburization. Atmospheres that carburize for short-time heating periods may eventually cause decarburization if the time in the superheat is sufficiently prolonged.

The retained austenite present on the surface after normal heat treatment can usually be broken down by a second draw at 1050° F. This accounts for the frequently reported superiority of tools that have been given a double-draw.

This steel is shown to be not susceptible to grain growth when treated from 2350° F. or lower. The composition of the furnace atmospheres used in the commercial heat treating furnaces studied did not affect the grain size or fracture characteristics. The only factors influencing grain growth are time and temperature, time being of secondary importance when temperatures of 2350° F. or lower are used.

In discussion, J. P. Gill pointed out that in commercial practice differences in atmospheres *do* have an effect on grain size when treatment is accomplished at the "same temperature." The effect, however, is one of the atmosphere on the *temperature of the tool,* which in turn exerts the expected influence on grain size. When temperature control is from outside the specimen, as it normally is, the observed temperature is seldom the actual temperature of the tool, and this discrepancy is affected by the atmosphere in contact with the tool.

Sam Tour expressed his conviction of some years standing that the soft skin on moly high speed steel after hardening in reducing atmospheres was due to retained austenite from carbon pick-up and not to decarburization. The "greater susceptibility to decarburization" of molybdenum high speed steels may not be that at all, but actually their greater austenite stability. (2a)

Bright Hardening of Steel

"Bright Heat Treatment of Steel." "Rova." *Sheet Metal Inds.*, Vol. 15, June 1941, pp. 745-753. Practical survey.

After discussion of the chemical reactions in furnace atmospheres, the article deals with their practical applications.

The simplest atmospheres that may be used are those obtained by controlling the degree of *combustion of gas, oil, coal or coke.* It is extremely difficult to obtain satisfactory atmospheres in this way and it is usually impossible to obtain surfaces

free from both oxidation and decarburization.

Coke is better than coal, as much hydrogen has been removed, giving a high carbon-monoxide content in a coke-fired atmosphere. Sulphur is deleterious as it causes rapid oxidation. Coke should be dry before use to prevent generation of steam with subsequent severe decarburization.

Combustion of gas mixtures must be incomplete for best results. Most satisfactory for coal gas is a ratio of air/gas of 2.5/1 (reducing, but decarburizing—satisfactory for mild steel) or 3.5/1 (slightly oxidizing and decarburizing). In the case of producer gas, an air/gas ratio of 0.8-1 is preferred from the point of view of surface reactions, but it is not economical as a means of heating because of the unburnt carbon monoxide and hydrogen passing into the stack. Furthermore, all sulphur should be removed in preliminary purification.

Useful also are *mixtures of burnt and unburnt gases,* where carefully controlled partially-burnt gas is used and produced in an apparatus outside the working furnace. Water and carbon dioxide must be removed before the atmosphere is introduced into the furnace. A positive pressure must be maintained in the working chamber to avoid leakage.

The best composition for such mixtures is easiest determined by running trials under exact working conditions. In mass production where only one grade of steel is involved, the atmosphere can be simply controlled by placing a "cartridge" containing turnings of the same steel heated to the same temperature as the furnace in the gas inlet line. Thus any harmful constituents react with this steel rather than with that in the furnace.

Small quantities of work may be heat treated quite satisfactorily by *pot annealing* —packing the articles in containers with either cast iron borings or powdered carburizing compound, which remove free oxygen from the entrapped air.

Charcoal gas requires less treatment than the partially burnt mixtures (water and usually carbon dioxide must be removed), but it is somewhat more expensive to produce. Freedom from decarburization is obtained only when hydrogen and water vapor are virtually absent from the mixture that reaches the furnace working chamber. Also, it does not invariably yield surfaces entirely free from scale, especially in the case of some stainless steels.

Cracked ammonia may be used as is, or a cheaper gas can be produced by burning the hydrogen and nitrogen with air, either partially or completely, followed by efficient drying. In the latter case, small additions of hydrocarbons may be used. The cracked ammonia method is rather expensive, but recirculation reduces the cost considerably.

Cracked hydrocarbons are also useful. The cracking may be done in the working chamber (although carbon deposition on the steel may occur), or, preferably, in a "cracker" from which the gas mixture is led to the furnace.

The best method of producing a bright heat treatment atmosphere depends on the details of the job in question. In general, the furnace should work at a pressure slightly above atmospheric to prevent ingress of air. Water vapor is so harmful that every source of moisture in the furnace must be eliminated (damp brickwork, damp jigs or work, cold damp tongs, steam from quenching tanks, etc.) JZB (2a)

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2b. Non-Ferrous

Purifying Plating Solutions

A Composite

The very great influence of mechanical and "chemical" cleanliness of the electrolyte on the quality of electroplates is now recognized, and modern plating installations include efficient filtering and purifying systems. The removal of mechanical contamination by filtering and of unwanted chemical contamination by chemical or electrochemical purification are described in recent articles.

Mechanical Purification

Clear plating baths are essential for the production of pore-free deposits, and S. Wernick & H. Silman ("The Technique of Filtering Plating Solutions," *J. Electrodepositors' Tech. Soc.*, Vol. 16, 1940, pp. 99-114) discuss the various types of filters in use. The filter press is not satisfactory for plating baths because of its tendency to leak, and because of the labor involved in cleaning and reassembling.

Candle filters are tubes made from Kieselguhr, compressed and fired. They give good filtration, but have the disadvantage of a low output of filtered solution because of clogging of filtering surface, and require a large amount of labor for disassembling and cleaning.

Filters precoated with Kieselguhr seem most satisfactory for plating baths. For a filter base, the British use a type of filter candle built up by stacking a large number of thin washers together on a slotted rod. American practice utilizes wood or ebonite grids covered by cloth or wool bags.

The centrifugal filter gives good results, but an installation large enough to give the rate of output required for a plating bath would be rather expensive. When continuous filtration is used, from 25 to 100% of the volume of the tank should pass through the filter each hour.

On filter installations, a pressure gage and a rotameter are useful to indicate the performance of the unit. Activated charcoal is recommended for removing organic contaminants from baths. Other subjects discussed are anode bags, filter pumps, and removal of impurities from plating baths.

Chemical and Electrochemical Means

The removal of metallic and organic impurities in plating solutions by chemical and electrochemical methods is a different problem. According to O. A. Stocker ("The Purification of Plating Solutions," *Metal Finishing*, Vol. 39, Sept. 1941, pp. 479-482), there are 3 general ways of removing such contamination—(1) precipitation and removal by filtration as a solid, (2) change in composition by chemical treatment so that the impurity may be removed by carbon filtration or its effect nullified, and (3) co-deposition of the impurity with the metal to be plated.

An aid to recognition and estimation of impurities is the bent cathode test or the Hull cell test—the former for low-current-density regions, and the latter for the whole range of current density from low to over 140 amps./ft.^{2}

The precipitation method is applicable to heavy metals in both acid baths and alkaline or cyanide baths and to carbonates in cyanide solutions. Precipitation by raising the pH is limited to solutions operating normally at pH value lower than that at which metals precipitate.

Changing the constitution of an impurity to cancel the bad effect is applicable to organic compounds, and comprises severe oxidation or reduction followed by activated carbon filtration to absorb the residue. This treatment is "special" and must be carefully worked out for each case to avoid destroying desirable organic constituents.

Co-deposition of the impurity with the metal being plated is very generally used. It is applicable to metallic and organic impurities, and is done with low current densities and a dummy cathode.

Specific Baths

Nickel baths are often purified by raising the pH to 6.2-6.4 by the addition of nickel hydroxide, nickel carbonate or calcium hydroxide, aided by hydrogen peroxide or potassium permanganate. This will remove practically any heavy metal including bivalent copper.

Precipitation of metallics may also be accomplished by adding finely divided iron or nickel powder to a nickel plating bath. Copper, lead and selenium will be "cemented" out on the powder, which must of course be purified. Then, if iron be used, any dissolved iron must be reprecipitated and filtered.

In copper cyanide solutions, the co-deposition of lead, thallium, cadmium, silver, zinc, nickel and tin is possible by dummy plating at low current densities. Excess carbonates may be removed by precipitation with calcium sulphate, barium chloride, barium cyanide, or by freezing out.

Acid copper, brass, cadmium, cyanidizing, and zinc and silver solutions are similarly discussed. The value of any of these purification methods lies in the fact that the operator can quickly bring a contaminated solution back to normal operation. A bath consistently purified every few weeks should never become a source of trouble.

Chromium from Alkaline Baths

A special instance of metallic contamination is the undesirable presence of chromium in a cyanide copper bath. M. M. Beckwith of J. B. Ford Sales Co. ("The Removal of Chromium Contamination from Alkaline Baths," *Mo. Rev. Am. Electroplaters Soc.*, Vol. 28, July 1941, pp. 543-549) points out that it reduces the cathode current efficiency, causes blistering and poor adhesion, and reduces the brightness of subsequently applied "bright nickel" deposits. Even 0.01 gm./l. of hexavalent chromium has an effect on the cathode current efficiency of a copper cyanide bath, and 0.1 gm./l. will reduce the efficiency to zero.

The hexavalent chromium is rendered harmless in the bath by reducing it to trivalent chromium with sodium hyposulphite, $Na_2S_2O_4$. The chromium precipitates out as hydroxide from the simple cyanide bath. In the bath containing Rochelle salts, the trivalent chromium forms a tartrate complex in which state it is harmless; but as the complex is oxidized at the anode to yield hexavalent chromium periodic additions of $Na_2S_2O_4$ must be made.

Sodium hyposulphite can also be used to remove hexavalent chromium from zinc and cadmium cyanide plating baths. An excess of several gm./l. of $Na_2S_2O_4$ has no harmful effect at the cathode. X (2b)

Flux Corrosion of Welded Aluminum

The Effect of Residual Hygroscopic Fluxes on the Corrosion Resistance of Welded Light Metal Tubes ("Der Einfluss von hygroskopischen Flussmittelrückständen auf die Korrosionsbeständigkeit geschweisster Leichtmetallrohre") E. von Rajakovics. *Autogene Metallbearbeit*, Vol. 34, Apr. 1, 1941, pp. 113-116. Investigation.

The complete removal of flux residues in the welding of pipes or hollow profiles often offers difficulties. At the same time, the use of non-hygroscopic fluxes is expensive, or even impossible with aluminum alloys of higher magnesium or silicon content of lower melting point than that of the flux.

Experiments were made to find out whether hygroscopic flux residues left inside pipes leads to serious corrosion. Pipes of duralumin were closed by welding and the flux was (a) left, (b) washed off only with water, and (c) properly washed with water, treated with 10% HNO_3 and again rinsed with water.

It was found that pronounced corrosion takes place if the flux residues are left and also if they were washed off with water only. No corrosive attack either in the heated zone or in the weld itself, however, could be observed after correct treatment with nitric acid.

Also, if the tubes were closed at both ends so that no moisture from the air could enter, the residue did not start corrosion. It is, however, recommended, in case hygroscopic fluxes are employed, always to treat with 10% HNO_3 and rinse thoroughly with water afterwards. Ha (2b)

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Design and Applications

3

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Metal Supplies and Substitution

A Composite

The metallurgical design engineer is vitally and obviously concerned with problems of metal supply, for his whole program of product manufacture is conditioned by the availability or scarcity of the metals he plans to use. But even with a clairvoyant picture of the future availability of industrial metals in the forms in which he employs them, he still must face the problem of selecting "plentiful" substitutes for those materials that are "short" or even under present pressure.

It is thus a double problem for the designer—what materials must be currently or ultimately replaced, and what available substitutes will be satisfactory? Recent surveys have provided some answers, as this digest will indicate.

Supplies

An excellent review of the supply situation as of Sept. 1st or thereabouts is given by E. E. THUM ("Conservation and Substitution Required by Metal Shortages," *Metal Progress*, Vol. 40, Sept. 1941, pp. 293-297), based on his own observations and on reports from OPM consultants at a meeting in August. In a nutshell, satisfactory supplies existed then for only 4 metals and the shortage included metals that were not even on the critical list 8 mos. ago.

For *aluminum*, facilities for producing between 500 and 700 million lbs. a yr. are now available, but demands will be in excess of 1400 million lbs. a yr. very soon. Capacity and power will not be available for production at this rate until Jan. 1943. The 10 million lbs. of "housewives' scrap" recently collected was sold to secondary smelters and will be used to make a high-iron mixture useful for killing steel.

Antimony is still satisfactorily available. There is about 1 yr.'s supply (750,000 tons of ore) of strategic *chromium*, so this metal must be rigidly conserved. *Copper* is practically a "precious" metal, with a total of 1,600,000 tons available and 1,250,000 tons of this needed for defense. If there is an increase in defense requirements, as is altogether possible, the available supply for civilian use may vanish.

Lead for the first time is under pressure, and its commercial condition is "worse than tin's." *Tin* a very "strategic" metal, is barely holding its own, with a small stock pile growing, through conservation and substitution. (Read "Tin Conservation" in METALS AND ALLOYS for August, p. 187.)

Mercury, also "strategic," is no problem at all and may never be one. *Zinc*, currently available for all defense and "basic" civilian requirements, will continue to be denied to nonessential-product manufacturers and may in time even be hard-to-get for essential demands.

Magnesium, with its normal 12 million lbs. annual production upped to 20 million this year and an increase to 34 million to be completed in 1942, seemed to be well in hand, at least for aircraft castings. But demands for fire-bombs and flares have raised expected demands to 400 million lbs. a yr., so that absolutely new and at present uncharted supply sources must be tapped.

Manganese, the most notoriously strategic metal, is a many-sided problem. At present we are holding our own, but demands are increasing and eventually can possibly be met only by full exploitation of low-grade domestic ore and use of our manganiferous iron ores—if indeed these measures will suffice.

Molybdenum, currently being used to replace just about everything else that is an "alloy" in steel, is officially believed to be available in easily adequate amounts, although the author believes that even with moly there is trouble ahead. *Nickel* is still very, very short, and subject to the most drastic kind of replacement wherever possible.

The *steel* situation is badly complicated. OPM has asked for a 10 million-ton increase in steel capacity, which is now just barely adequate for munitions, defense, essential-industry, lease-lend and basic civilian requirements. This increase in capacity will itself consume about 4.2 million tons of steel for plant. The steel shortage is as much a shortage of pig iron and scrap as of insufficient open hearth and rolling mill capacity. The scrap supply can be augmented by intensified collection and concentration, but no added pig iron capacity can become effective for 15 months.

Substitutions

A broad review of resourcefulness and ingenuity in finding and using American-made substitutes for these hard-to-get metals is given by H. W. GILLETT of Battelle Mem. Inst. ("Made-in-America Substitutes," *S.A.E. Journal*, Vol. 48, June 1941, Trans. pp. 205-212). Expedients that can be used in the case of the "have-not" metals are stock-piling; utilization of low-grade domestic raw materials; and substitution of an entirely different material, of

AERIAL PHOTOGRAPH TAKEN SEPTEMBER 12, 1941

domestic origin, that is equally serviceable.

Stock-piles have the advantage of requiring no new technology and no new equipment, but no one knows how long a war will last. Utilization of low-grade materials is costly and slow as it involves time and expense for construction of plants to manufacture usable finished products from the unaccustomed raw material, and, when there is no usable technologic background, it involves development from the ground up of the utilization processes. The use of a real substitute is the best expedient.

About 20% of the uses for *tungsten* are not readily replaceable, but this is far more than covered by domestic production. The remaining 80% of tungsten goes into high-speed steel and this is very largely replaceable by molybdenum, of which we have a large domestic supply.

The major use of *antimony* is in storage batteries. The 10% of antimony in the average battery grid can be satisfactorily replaced by 0.1% calcium, which is now made here.

The demand for *chromium* has increased greatly in recent years, and there is no obvious substitute for our most important needs, such as corrosion-resistant stainless steels, and heat-resistant and electrical resistor alloys. Other alloy steels and irons can be largely substituted for many commercial uses, such as in S.A.E. steels and in alloy cast iron.

The most practical substitute for *tinplate* for food cans appears to be black, untinned plate, with lacquer linings such as are used in beer cans. Tin is used as a coating to facilitate soldering the joint of the can body, but it has been demonstrated that the joint can be replaced by other types. The aircraft industry is using a 95% Pb, 5% Ag solder on radiators for glycol-cooled engines. A 97.5% Pb, 2.5% Ag solder is usable for nearly every ordinary solder use. Other usable solders are 82.5% Cd, 17.5 Zn; 95% Cd, 5 Ag; and 85% Pb, 15 Cd plus a little zinc.

Tin bronzes ordinarily can be replaced by silicon and other non-tin bronzes. Such bearing bronzes as 80% Cu, 5 Sn, 5 Ni and 10 Pb can probably be substituted for 80% Cu, 10 Sn and 10 Pb in many cases. Battelle Memorial Institute is developing a lead-base Babbitt that more nearly approaches tin-base Babbitt than the alloys heretofore suggested.

Gold plating gives good bearing surface, and gold-lead alloys make good bearings. Substitution of cadmium for tin is solder and Babbitt is limited by the cadmium supply; actually, we have a much smaller supply of this metal than of silver and gold.

Substitutes for *manganese* have received very limited attention. Using other elements for alloying effect can reduce but a small proportion of the total needs for manganese, since its tonnage use is as a "conditioner" of all steel. Titanium and zirconium have been proposed as manganese substitutes, but the evidence regarding their effectiveness is scanty and inconclusive. Study of these elements as manganese substitutes should be carried on to a real appraisal of their possibilities and limitations.

Research to find substitutes should be encouraged and we should not rest content until the strategic materials we must still import are wiped off the list.

Designing with Substitutes

The experience of metallurgical engineers in the automotive industry in substituting plentiful materials for hard-to-get metals (as of May 1941) is surveyed by THOS. A. BISSELL ("Designing for Alternate Materials," *S.A.E. Journal,* Vol. 49, July 1941, Trans. pp. 249-259).

The most important design problem in the entire program is the replacement of aluminum alloy pistons by other materials. Cast iron or cast steel substitutes have been developed. Cast iron pistons are about 50% heavier, have less than ½ the thermal conductivity, and about ½ the thermal expansion of aluminum alloy pistons.

The result is that the piston pins, connecting rods, and connecting rod bearings must be checked for strength and rigidity against the higher stresses; the cooling system, against the lower thermal conductivity; and the piston pin fit, against the lower thermal expansion. Often, the compression ratio must be lowered and spark timing altered. The recently adopted thin-Babbitt main and connecting rod bearings have adequate excess capacity to handle the higher stresses.

Cast iron pistons require different and more extensive machining and grinding operations, so that a complete new machine tool set-up is required. The extent of use of cast iron pistons depends upon the future availability of low grade aluminum alloys (containing a maximum of 87% Al, all remelted from scrap).

For brake piston wheels of extruded high grade aluminum alloy, low grade aluminum cast in permanent molds was approved as a substitute over powdered metal, cast iron, screw machine steel, welded steel forgings, and special glass. Injected plastic brake wheel pistons have been developed as an optional alternate, should the supply of low

grade aluminum alloy be shut off. Experiments are being made with coated pulverized iron and plastics for brake cylinders.

Several companies report that 80% or more of nickel will be eliminated from their passenger cars. The biggest problem is replacing the nickel alloy steels because of the modifications necessary in machining and heat treating, and sometimes in the design of the part itself. Nickel steels do not have to be controlled and supervised in production as closely as do most other steels.

The trend toward replacing nickel steels by other steels for parts of power-transmission and steering systems started some time ago. One company is changing from S.A.E. 3100 (nickel-chromium) and S.A.E. 4600 (molybdenum-nickel) steels to S.A.E. 4100 (chromium-molybdenum), S.A.E. 1300 (manganese) and S.A.E. 5100 (chromium) steels. Some companies are retaining the S.A.E. 4600 steel for gears but eliminating all other nickel steels. Many are experimenting with the low-alloy high-tensile steels.

All 18-8 chromium-nickel steels used for decorative purposes are being eliminated. Substitutes include copper plate for small moldings, 18% Cr steels, and chromium-plated carbon steel. Some manufacturers contemplate eliminating almost all moldings and trim.

If permitted to have nickel-steel alloys in only one part, many engineers would retain them in the exhaust-valves, because the chromium-nickel steels used show the greatest resistance to oxidation and corrosion by the exhaust gases and to the excessive heat. Exhaust valves containing 7-18% Cr and 2-3½ Si are performing satisfactorily, but substitution of these in engines designed for nickel-chromium valves either would have far-reaching effects on design out of all proportion to the weight of nickel saved, or would result in a loss in performance and lower valve life. In cast iron and cast steel, properties conferred by nickel can be obtained by increasing silicon or by substituting other non-nickel alloying combinations.

Recent developments in nickel plating will result in reducing the amount of nickel in the plate from an average of 1½-2 lbs. in present cars to an average of ½ lb. in 1942 models. This has been made possible by using bright copper, which is 3 or more times thicker than the dull copper used previously, in conjunction with a special bright nickel. Indium, cadmium and silver plating have been suggested as substitutes, but the consensus is that exterior plating will be eliminated if nickel for this purpose is cut off.

Indications are that 50-80% of the zinc formerly used in passenger cars will be taken out of 1942 models. Greatest savings will be in the elimination of zinc-alloy die castings for decorative parts. Plated stamped steel or antimony-lead dies castings will be used for radiator grilles.

Much work is being done on development of plastic alternates for zinc die castings, but there is a difference of opinion regarding their adequacy for carburetors and fuel pumps. A number of other zinc alloy die castings are being replaced by plastics, pressed steel, cast iron and steel forgings and stampings.

Brass tubes and tanks in radiators are being changed to copper. If copper becomes scarce, specially painted or terne-plated steel may be used, although not as suitable. In some radiators, a small amount of silver is added to copper used for fins to stiffen them enough to permit punching of holes.

Should the use of chromium be restricted, 18% Cr steels used for body molding and trim will be replaced with striped painted trim or with plated carbon steels or plated copper. If manganese, molybdenum, vanadium, zirconium and silicon were still available, it is believed that satisfactory substitutes could be developed for chromium steels used for parts of transmission and steering systems, although more generous sections might be required to compensate for possible deficiencies in impact strength.

Some metallurgists contend that carbon-molybdenum steels could be substituted throughout the entire car with exception of the exhaust valves and ball- and roller-bearings. The chromium used in cast iron can be replaced by other elements. Chromium plating is much more likely to be abandoned because of the shortage of nickel or copper than of the small amount of chromium used.

These and many other described substitutions, made or definitely planned, will entail no lowering of the standards of safety, durability, performance and comfort established in the 1941 cars. In virtually all cases, however, parts of alternate materials cost more than do the original parts made of critical materials. X (3)

Powder-Metal Bearings

"Porous Metal Bearings." *Product Engineering*, Vol. 12, Sept. 1941, pp. 496-500. Review.

Porous metal bearings have a wide range of service. In general, these self-lubricating bearings are not recommended for extreme impact and high pressure service. They have proved superior to cast bronze, however, where medium to high speeds are encountered with fairly balanced loads.

Standard design practice for solid bronze bearings may be used for sintered bronze bearings. Any design changes are towards simplification.

Self-lubricating bearings are not confined merely to applications where they hold sufficient lubricant to last the life of the machine in which they are used. An additional reservoir of oil can be provided by coring or machining cavities in the bearing housing. A continuous supply of oil to maintain a lubricating film on the bearing is important for successful performance. Any tendency of a bearing to heat is counteracted by expansion of the oil within the bearing pores, which generally constitute 25-35% of its volume.

The elimination of the messiness of grease is a decided advantage over the cast type bearing. Blow holes and other casting defects are avoided, and uniformity of structure is assured by pre-determining weight and dimensions.

Porous metal bearings can be mounted with closer tolerances than are possible with cast and machined bearings. A hardened steel plug is used to maintain bore size and alignment is a simple press operation. Reaming is both unnecessary and undesirable. Although porous bearings may be machined, this is discouraged because it seriously impairs the self-lubricating properties.

Permissible bearing pressure for self-lubricating bearings is said to be the same as for plain bronze installations. However, there are so many variables present that recommendations regarding loads, speeds, clearances, etc. are impossible in borderline applications. Composition, hardness, etc. must also be considered.

The type of lubricant to be used is determined by the service in which the bearing is placed. The life of the oil in a sintered bearing depends upon the degree of porosity, operating temperatures and wall thickness of bearing.

Materials from which porous bearings are made vary somewhat with the manufacturer. Bronzes have proved particularly desirable. However, since a characteristic of copper is its catalytic effect upon the oxidation of oil at high temperatures, manufacturers have used pure iron in some applications.

Normal bearing wear does not close off the pores of a porous bronze bearing. Galling, scoring, and incorrect machining will close the pores.

Powdered iron bearings have 3 advantages over bronze: (1) they will withstand higher bearing pressures, (2) there is an absence of catalytic effect on oil, and (3) lower cost of material. But, the self-lubrication of powdered iron bearings is not as positive as in bronze bearings, and more rigid specifications for bearing alignment are necessary for bearings of powdered iron. (3)

3a. Ferrous

Titanium in a Chromium Steel

"SOME EFFECTS OF TITANIUM ON LOW CARBON 1 PER CENT CHROMIUM STEEL." JOHN N. PAPPAS & MORRIS COHEN. *Iron Age*, Vol. 148, July 31, 1941, pp. 29-34. Original investigation.

The effect of titanium on the mechanical properties of a 1% Cr steel with 0.20% C was studied. The steels were prepared in a 17-lb. induction furnace.

The following conclusions were drawn: The addition of aluminum, titanium or vanadium to a 1% Cr steel with 0.20% C raises its coarsening temperature. The effectiveness of the elements decreases in the order named.

The addition of titanium to the above low-carbon 1% Cr steel lowers strength and raises ductility and impact value. Titanium not only deoxidizes and refines the grain, but has specific alloying action as well.

Aluminum and titanium inhibit air hardening after normalizing up to 1850° F. After normalizing at 2050° F. the air hardenability of titanium-bearing steels increases. Vanadium in the absence of aluminum or titanium raises air hardenability after normalizing at 1850° F. or above.

In "pseudo-carburized," heat-treated, quenched-and-tempered steels, titanium contents between 0.025 and 0.25%, produce a wide range of mechanical properties. Low-titanium steels exhibit high strength with moderate ductility and impact resistance, while higher titanium steels exhibit moderate strength with high ductility and impact resistance.

The combined use of aluminum and titanium may be advantageous in obtaining certain properties with less titanium than would be required in the absence of aluminum.

Hardened vanadium-bearing steels show greater ability to retain their strength after tempering than non-vanadium steels. This property is not impaired by reducing the vanadium from 0.16 to 0.09% and in replacing it with about 0.03% Ti. This gives an excellent balance of properties.
VSP (3a)

Cast Iron for Machine Parts

CAST IRON FOR HIGH-GRADE MACHINE PARTS AND AS SUBSTITUTE MATERIAL ("Gusseisen fur hochwertige Maschinenteile und als Austauschwerkstoff") F. ROLL, *Maschinenbau-Betrieb*, Vol. 20, Mar. 1941, pp. 127-129. Practical.

For best wear resistance in cast iron, a lamellar matrix with medium size graphite particles and high combined carbide content are desired. Nitriding further improves resistance to wear, especially in alloy cast irons.

In some cases phosphorus additions are advantageous; the impact resistance does not suffer if phosphorus is kept below 0.5% P. Cast iron can thus be used for cams, sliding surfaces, cylinder bushings and bearings. Machinability can be improved for screw machine work by annealing.

Volume changes under alternating temperature conditions are eliminated by properly adjusting the silicon content. In order to insure permanent stability in size for instrument parts, stress relieving heat treatment is carried out at 660° F. to 850° F., or in oil at 300° F.

As compared with low-carbon steel cast iron shows a much lower rate of rust formation under flowing water. The cast skin is particularly valuable for corrosion resistance. High grade cast iron is practically scale-free up to 1150° F. RPS (3a)

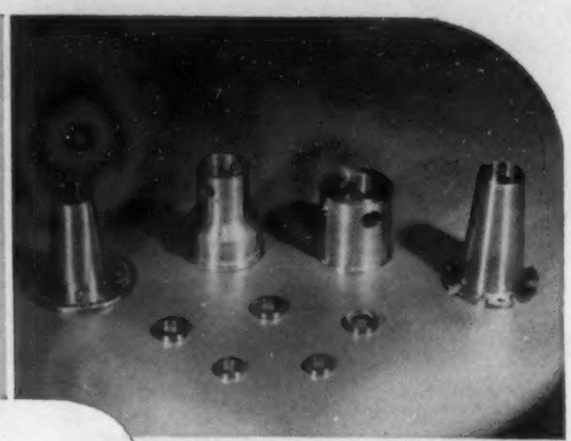
Stainless Steel Welded vs. Cast vs. Rolled

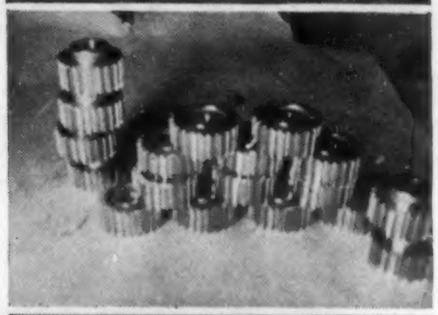
"COMPARISON OF THE PROPERTIES OF 18-8 WELD METAL, CAST METAL AND ROLLED METAL." K. W. OSTROM & R. D. THOMAS, JR. (Arcos Corp.) *Welding J., N. Y.*, Vol. 20, July 1941, pp. 317s-323s. Comprehensive research.

The metal-forms compared were the as-cast ingot, the hot-rolled ingot, the as-cast weld metal (made with electrodes rolled from the ingot), and the hot-rolled weld metal.

The original ingots were 11 in. sq. and 5 ft. high; they were hot-rolled to ¾ in. round bars for the as-rolled studies. The ¾ round bars were hot-rolled to 9/16 in., cold-drawn to 3/16 and flux-coated. Solid blocks of weld metal 2 x 5 x 11 in. were deposited with the electrodes for the as-welded studies. Another block 4½ x 4½ x 5 in. was deposited with welding, then forged and hot rolled to ¾-in. round bars.

All of the materials were tested in the conditions of (1) as-received; (2) annealed at 1950° F. for 15 min., water-quenched; (3) annealed at 2300° F. for 60 min., water quenched; (4) sensitized 4 hrs. at 1200° F. after treatment (2). The physicals determined were yield strength, ultimate strength, elongation,





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For years before the defense program was under way, Ampco was serving American industries, helping build the quality for which American products are famous. The high tensile strength, controlled hardness, and resistance to wear and corrosion of Ampco-made bronzes were early recognized by designing engineers as necessary for satisfactory equipment performance.

Catalog number 22—brand new—shows why Ampco Metal is preferred by defense contractors.

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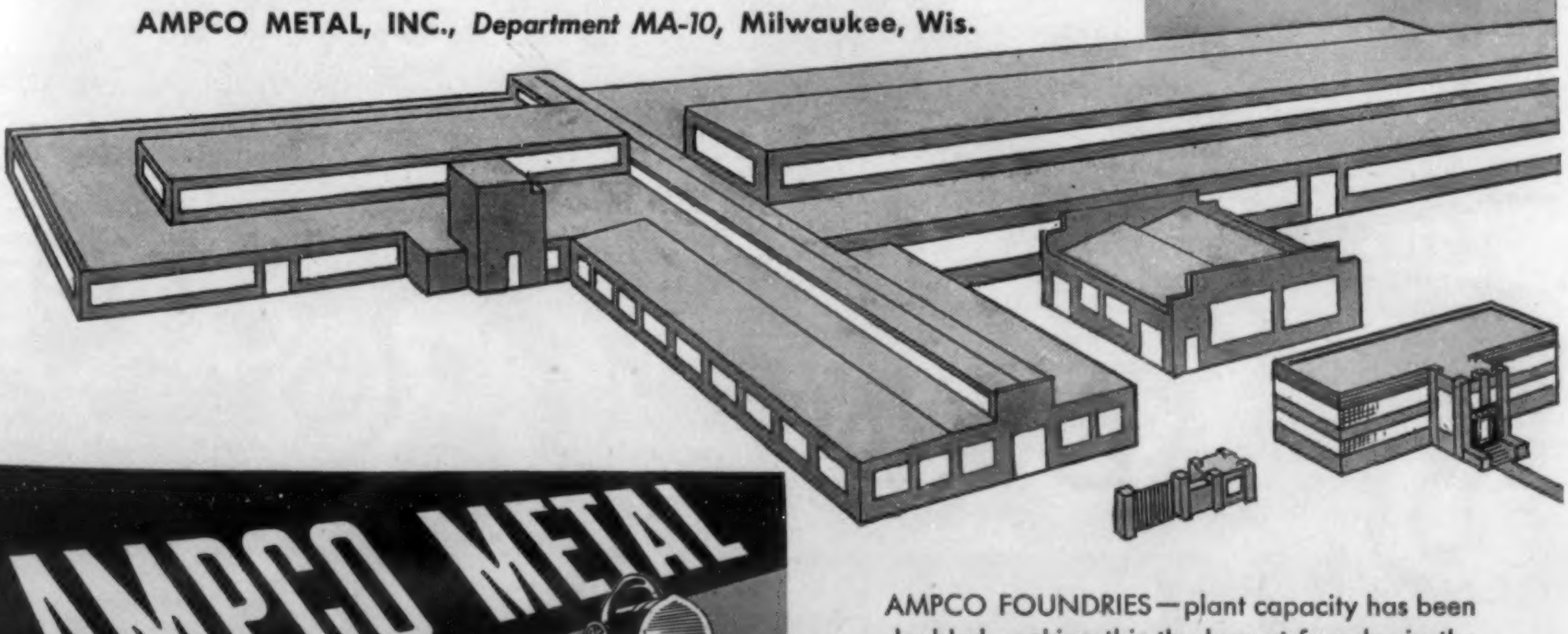

AMPCO METAL

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AMPCO FOUNDRIES—plant capacity has been doubled, making this the largest foundry in the country devoted primarily to the production of aluminum bronzes of controlled analyses.

Izod value and hardness. Corrosion tests were made for 5 periods of 48 hrs. in boiling, concentrated nitric acid.

The ultimate tensile strength of the cast ingot was considerably lower than the other forms of the alloy. The weld metal in the as-welded condition had slightly lower strength than either of the hot-rolled metals, but higher than the as-cast ingot.

The grain sizes of the as-cast ingot and of the weld metal are large, but decreased in this order. For the as-hot-rolled metals the grain size is a minimum, and these have the maximum yield and ultimate strengths. Any of the heat treatments applied to the as-hot-rolled metals results in a decrease in strength.

The ductility of the ingot material in the as-cast and hot-rolled conditions was better than that of the weld metal for either condition, which might be associated with the high dispersion of inclusions in the weld deposit. The sensitizing 1200° F. treatment does not result in loss of ductility or impact, and ductility appears to be a rough indication of the impact value.

The corrosion rate of the 1200° F. sensitized specimens is a maximum for each form of material. The annealed specimens had minimum rates of corrosion. The annealed weld deposit had a slightly higher corrosion rate than the annealed ingot specimens. The presence of ferrite, found to a considerable extent in the as-cast ingot and slightly in the as-cast weld metal, does not affect the corrosion rate, since the as-cast ingot specimens had a slightly lower corrosion rate.

Differences in the corrosion rate of the metals formed by the two processes are largely due to the amount of carbides present. The minimum in corrosion rate for weld metal may be attained by annealing or by increasing the cooling rate during welding.

Micrographic studies, which are illustrated, indicate that ferrite, formed above 2050° F. in the cast ingot and weld metal, can be made to dissolve completely at annealing temperatures with sufficient time; mechanical work prior to annealing aids the process of ferrite solution. In both ingot and weld metal, the carbides preferred to segregate at ferrite patches rather than on grain boundaries, but when sensitized at 1200° F. the grain boundaries are outlined by carbides. WB (3a)

Cast Iron at High Temperatures

"Some Factors Affecting the Resistance of Cast Iron to Deflection under Load at High Temperatures." L. W. Bolton. *Foundry Trade J.*, Vol. 65, July 3, 1941, pp. 3, 4, 7; July 10, 1941, pp. 17, 18, 24; July 17, 1941, pp. 44, 46, 48. Investigation.

Special attention has been given in this work to the influence of graphite size, variations in silicon and phosphorus contents, and to alloying employed to the extent of rendering the structure of the iron austenitic. Some data on carbon steels of varying carbon content have also been obtained.

A method of testing has been developed, which consists essentially of transverse-loading a bar of standard dimensions at one end while the other end is rigidly held, the stressed portion of the bar being held at a predetermined constant temperature. Apparatus and method employed, influence of silicon, phosphorus and graphite-size on rigidity of cast iron at 1560° F., rigidity of carbon steel, and heat-resisting cast irons at 1560° F. are discussed.

Silicon exerts a stiffening influence on cast iron, the rigidity of castings being increased as the silicon is increased. The scaling of the silicon-iron specimens was only superficial. The high-silicon irons, which are extremely brittle in the cold, were found to bend under prolonged stress at 1560° F. The bar containing 13.77% Si gave permanent deflection of 0.86 in. at the free end of the test-piece under a stress of 3,750 lbs./in.² after 12 days at this temperature.

The results of these tests show that additions of silicon of the order of 7% and more considerably increase the resistance of cast iron to deformation under load at high temperatures. Since the phosphide eutectic melts at a temperature of approximately 1760° F., at temperatures of this order the presence of relatively small quantities of phosphorus is sufficient to cause almost complete loss of mechanical strength.

The austenitic irons Nicrosilal and Ni-Resist were found to have good resistance to deflection at 1560° F. It appears that gray cast iron for high-temperature service should have as fine a graphite structure as possible.

Three plain carbon steels were tested, and it was found that these had less resistance to deflection at 1560° F. than many of cast irons examined. If the service conditions entail heating the casting slowly to a uniform temperature, it is thought that an iron that is highly resistant to deflection will give better service than one that is less resistant. On the

other hand, if the service conditions are such that the casting is subjected to steep temperature gradients, then it is possible that some stiffness must be sacrificed, and less rigid iron will be better able to withstand these conditions. AIK (3a)

3b. Non-Ferrous

Tin Application Developments

"TIN IN FOUNDRY PRACTICE." *Foundry Trade J.*, Vol. 64, June 5, 1941, p. 374. Extracted from the Annual Report of the Tin Research Institute.

Electro-deposition of white tin bronzes, tin-rich alloys, bearing metals, pewter and the use of tin oxide in the vitreous enamel industry are discussed.

The best composition of the white bronze alloy deposit for resistance to atmospheric tarnishing is found to be 40-45% Sn, the balance being copper. White bronze appears on the whole to be slightly less tarnish-resistant than chromium, but is more easily repolished.

Research was undertaken to find an alloy more suitable for ships' underwater bearings than the alloy at present in use. One tin-rich alloy of outstanding superiority containing a higher percentage of tin than that now used is recommended. Among the large number of new tin-rich alloys examined, two containing over 90% Sn have been selected for development of new or improved pewters.

Bronzes having better properties for many purposes have been made in the laboratory by adding small quantities of aluminum and casting by a new technique. The rolling properties of these alloys are extraordinarily good, and their mechanical properties in the annealed condition are superior to those of the best alloys in use for condenser tubes; corrosion resistance remains to be determined.

As a guide to the selection of alloy compositions, the constitution of the series of alloys containing 5 to 18% Sn and nil to 7% Al has been worked out. Preliminary corrosion tests in sea water suggest that the alloys may be particularly useful as condenser tubes. AIK (3b)

Condenser-Tube Alloys

"SERVICE EXPERIENCE WITH THE NEWER CONDENSER-TUBE ALLOYS." *Mechanical Engineering*, Vol. 63, Sept. 1941, pp. 653-656, 658. Research.

Admiralty, Muntz and arsenical copper for condenser tubes have been supplemented during the past decade by a new group of alloys including among others aluminum brass, aluminum bronze, copper-nickel, copper-nickel-zinc, and copper-nickel-tin, to meet the demand for condenser tubes with superior corrosion- and erosion-resistant properties. The A. S. M. E. Special Research Committee on Condenser Tubes in its 1940 Report has surveyed experience with this new group of alloys in the condenser tube field.

The aluminum-brass type is being employed in increasing amounts in power station condensers using salt water. The 70 copper-30 nickel type showed the best all-around corrosion resistance to salt water aboard naval vessels. However, the copper-nickel alloys have not proved satisfactory around tidewater and contaminated harbor water. High copper-tin-bronze will give longer service where circulating waters are high in acid.

A public utility company on the West Coast using sea water at velocities of 5-6

THE PROPERTIES OF LEAD

Work Hardening & Resistance to Flexure Failure

A test to measure the increase in hardening due to cold working was devised, and the following results were obtained on various grades of lead and some of its alloys.

DESCRIPTION OF SPECIMEN				INCREASE
Corroding Lead	99.99+%	(.006 Bi)	— Rolled	1%
Common Lead	99.85+%	(.12 Bi)	— Rolled	2%
Corroding Lead	99.998%	(no Bi)	— Rolled	3%
Common Lead	99.98+%	(.002 Cu)	— Rolled	12%
Chemical Lead	99.92+%	(.06 Cu)	— Extruded	9%
Tellurium-Lead		(.06 Te)	— Extruded	26%

These results were obtained with loads of 1100 grams. Extruded calcium lead alloys containing .03% Ca were tested at higher loads, as follows:

	1300 grams	1500 grams	1900 grams	2100 grams	2200 grams
Increase in Hardening	16%	22%	22%	23%	18%

Resistance to failure by bending was tested by subjecting strips of lead under stress of 200 pounds per sq. in. to reversed 90° bends made alternately over 5" diameter rolls at a rate of 11 cycles per minute.

GRADE OF LEAD	PREPARATION OF SPECIMEN	CYCLES TO FAILURE	PERCENT ELONGATION
Common Lead 99.85+%	Extruded	72	49
Chemical Lead 99.92+%	Extruded	103	52
Corroding Lead 99.99%	Extruded	54	35

The properties of work hardening and failure by bending, are of interest where the lead in its application is subjected to cyclic loading or flexing.

•

Shown at right are lead lined steam separators (4' x 6' 6¾") in chemical plant.

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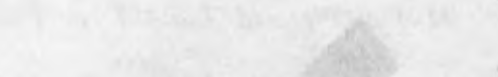
Information based on rather wide experience and our co-operation are offered to the manufacturer with a serious interest in the application of parts or material produced by powder metallurgy.



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Testing and Control 4

METHODS, EQUIPMENT

Physical and Mechanical Property Testing and Inspection. Routine Control and Instrumentation. X-ray and Magnetic Inspection. Spectrographic and Photoelastic Analysis. Corrosion- and Wear-Testing. Examination of Coatings, Surface Measurements. Metallographic Structure and Constitution.

X-Ray Analysis in Industry

A Composite

X-ray analysis is a comparatively recent development, immature, incompletely understood and insufficiently appreciated. Many different laboratories and groups of workers are carrying out work in X-ray analysis, and each independent group has usually built up its own technique. Many improved methods have been developed and new applications discovered.

Although descriptions of some of these methods and applications have been published from time to time, there has been no concerted effort to bring the material together and organize it so that a general picture can be had of the progress in X-ray analysis thus far.

The *J. Scientific Instruments,* an English publication, has taken the initiative for closer collaboration in this field by publishing a series of papers in its May and July 1941 issues, which summarize the many methods and applications developed in England.

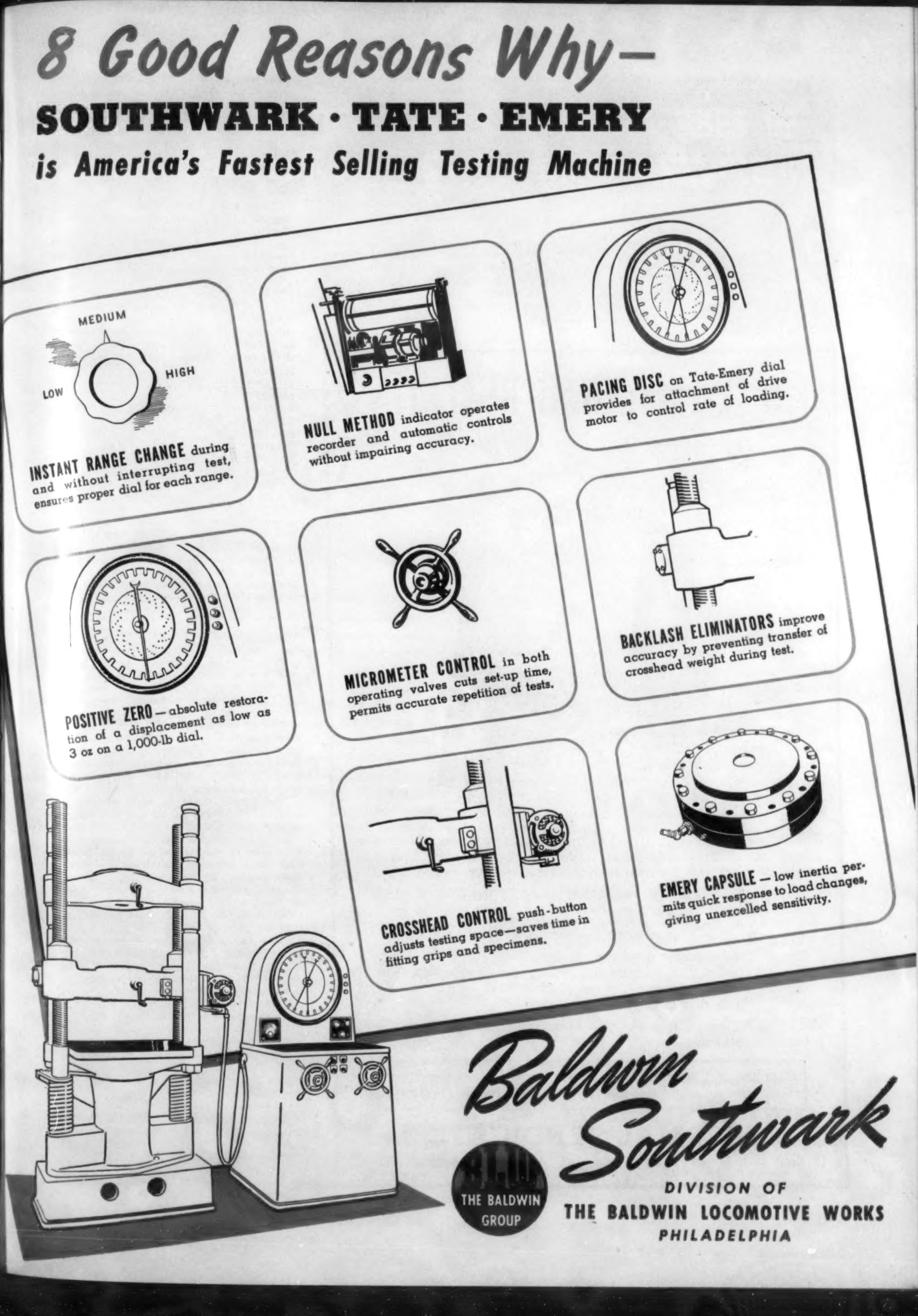
The papers do not discuss the highly specialized art of crystal analysis but are devoted mainly to the many other characteristics of the solid state that can be determined by X-ray analysis. Technique and interpretation are stressed.

Industrial Applications

W. Hume-Rothery & G. V. Raynor (*J. Sci. Instruments,* Vol. 18, May 1941, pp. 74-81) compare the relative advantages of the X-ray and classical methods for the determination of phase boundaries in metallurgical equilibrium diagrams. The classical methods are best for the determination of the liquidus and solidus curves, but for the determination of the solid solubility curves, and transformations in the solid state, the method of thermal analysis is inferior, owing to the sluggishness of transformations in the solid state.

Most solubility curves are now determined by microscopic methods. The alloy in lump form is annealed to produce equilibrium, quenched and examined microscopically to see how many phases it contained at the quenching temperature.

Most X-ray investigations involve the use of filing. It is necessary to obtain the filings in a state of true equilibrium. A lump of the alloy is annealed, quenched from the temperature concerned, after which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filings are prepared and re-annealed to the same temperature.

At lower temperatures the X-ray method is valuable, provided that specimens are given suitably long annealing treatments. The idea that X-ray methods permit phase boundaries to be determined accurately with a few alloys must be discarded.

At higher temperatures the classical methods become relatively more suitable. In diagrams involving superlattice formation, the X-ray method is the best.

The conclusion reached is that the two methods should be used in conjunction for the best results.

A. H. JAY (*Ibid.*, pp. 81-84) summarizes a number of X-ray investigations performed in a steelworks research laboratory.

A case was examined of the effect of over-annealing during the softening treatment on the magnetic properties of the finally hardened steel. The X-ray method used for the specimens consisted of directing a slit-shaped beam on to the surface of the block and receiving the side reflections on a flat film placed to face the specimen.

Transformer steel sheet was examined by X-ray and showed that crystal size can be correlated with magnetic watt loss values.

The X-ray powder diffraction method of investigation has become increasingly more valuable. H. P. ROOKSBY (*Ibid.*, pp. 84-90) discusses the method and some aspects of the experimental technique. A very practical application of this method is to distinguish between an alloy and a mixture of two metals.

X-ray examination of mechanical wear products, a new approach to a problem of great complexity, is presented by H. J. GOLDSCHMIDT & G. F. HARRIS (*Ibid.*, pp. 94-97). A wear testing machine was used (Avery-Brounsdon), and the fine powder formed by the abrasion was examined in a 9 cm. diam. Debye-Scherrer powder camera.

The photographs showed highly diffuse diffraction lines, indicating a very small particle size or severe internal strains. The abrasion products consisted of mixtures of ferrite and iron oxide. The oxides were FeO and Fe_3O_4. Small amounts of cementite were also present in certain cases. The amounts of alpha-iron, FeO and Fe_3O_4 in the wear powder depended on the steel composition, phase constitution and certain experimental factors.

In a paper entitled "The Spoiling of Tungsten Magnet Steels" (*Ibid.*, pp. 97-98), C. WAINWRIGHT describes an X-ray examination of the structural changes occurring in tungsten magnet steels during heat treatment. Bars of tungsten steel were given various treatments and then examined.

It was found that both unhardened and hardened steels gave only the lines of alpha-iron. After soaking in the spoiling region, the double carbide of Westgren and Phragmen and tungsten carbide lines were present. As soaking proceeded, original diffuseness was progressively reduced until the doublets were completely resolved.

Also, residues remaining after electrolytic solution of the iron reproduced the above processes of carbide formation. From the normal steel, the residues gave no spectra; after spoiling, both Fe_4W_2C and WC were present.

Finally, there was no evidence for the existence of cementite under any conditions. Hardening of the steels caused only minor modifications in the carbide lines.

Technique

"Experimental Technique in the Study of Alloys by X-rays" (*Ibid.*, July 1941, pp. 131-133), a paper by OLIVE S. EDWARDS & H. LIPSON discusses ways of overcoming difficulties arising in taking X-ray photographs of metals and alloys. The experimenter must have available several different characteristic radiations. To obtain these, it is necessary to use a continuously evacuated X-ray tube with at least 6 interchangeable target holders.

The target should be efficiently water-cooled. The focus of the electron stream on the target should be a horizontal line.

In order to eliminate beta-radiation, a filter must be used which has an absorption edge lying between the alpha- and beta-wave-lengths. By the use of larger cameras, clarity is gained and the separation of lines on the film is increased.

W. A. WOOD (*Ibid.*, pp. 153-154) surveys the principal changes in structure of a metal during deformation as brought out by application of X-ray diffraction methods. In the elastic range, the grains preserve their integrity; at the yield stress, there is a breakdown into smaller components of differing orientations; at fracture, the identity of the grains is lost.

The X-rays show that the grains do not break down continually into smaller and smaller components as deformation proceeds, but only to a well-defined lower limit. X-rays also show the existence in the breakdown process of a speed effect.

X-rays have shown that up to the external yield point, the contraction of atomic spacing is proportional to the applied stress and that as the stress is increased beyond the external yield point, the contraction of lattice spacing slows down and rapidly reaches a limiting value. (4)

Weldability Testing

"Investigation of the Single Bead Weldability Test." A. M. Manlove (Ordnance Dept., U. S. Army) *Welding J., N. Y.*, Vol. 20, July 1941, pp. 324s-328s. Research report.

The variables in the single bead welding test and their effect on the test data are surveyed. The single bead welding test has been developed at Watertown Arsenal, and is considered as a simple, dependable weldability test, which can be made at low cost and in a short interval of time. Its weakness as a test for weldability is that hardness alone will not distinguish between toughness and brittleness.

The Arsenal has made the test a standard for analysis and further development. The data reported are for S.A.E. 1020 and 1045 steels in tests to determine (1) that section of the plate at which highest hardness is induced by the heat effect of welding, (2) the effect of length, width, and thickness of plate, and (3) the effect on temperature of several points on the bottom surface, and within the plate by variation in plate dimensions.

The author finds the maximum hardness in the heat-affected zone is induced under the crater. The lowest hardness is at the initial point of the bead. Reasonably constant hardness is obtained underneath the body of the bead between those two points.

Increasing the plate width from 3 to 6 in. and the length from 6 to 9 in. does not appreciably affect the hardness values, but an increase in thickness from ½ to 1½ in. causes an appreciable increase in sectional hardnesses. The determination of peak temperatures at points within the plate, at the bottom surface directly under the center of the weld, where peak temperatures of around 1300° F. were attained, does not furnish a definite index to the hardenability of the heat-affected zone.

All of the hardness tests were made with the Rockwell Superficial tester, and in order to obtain a mean and fair representation of the maximum hardening, the average of the 5 hardest readings in any section was arbitrarily taken as the maximum induced hardness for that section. Slight disparities in the average maximum hardness appear to exist on various sections taken from the single bead welded plate between the start and the crater, but in every case the minimum and maximum hardnesses are reported for the start and crater hardness surveys respectively.

WB (4)

Photoelastic Analysis

A Composite

Stress analysis by means of photoelastic studies of transparent models with polarized light is increasingly employed by metallurgical design engineers to resolve problems of shapes and sections of metal structures under design. A symposium on the status of the new technique was published in the August issue of *J. Applied Physics*.

In the first paper, R. Weller of Washington State College ("Three Dimensional Photoelasticity Using Scattered Light", *J. Applied Physics*, Vol. 12, Aug. 1941, pp. 610-616) reviews a new method of stress analysis in which a beam of light is polarized and passed through a narrow slit to give a plane beam, which in turn is passed through the transparent test model at any desired section.

The light scattered from this illuminated section is polarized and analyzed within the model itself so that in the section will ap-

pear interference fringes from which the stresses in the chosen section may be determined. From a study of a number of such sections the stress distribution within the whole test sample may be derived.

The apparatus required is somewhat simpler than that used in conventional photoelastic methods and is fully described and discussed together with attendant experimental difficulties.

A new approach to problems involving dynamic loading and vibratory stress is offered by W. M. MURRAY of Mass. Inst. Tech. ("Photoelastic Study in Vibrations," *Ibid.*, pp. 617-622). The application of stroboscopic methods to photoelastic examination to determine instantaneous stress distributions existing during dynamic loading is described. The theory and the experimental technique for a particular type of problem including an ingenious mechanical device for creating controlled dynamic stresses are described.

The need for a universal method of predicting or avoiding stress concentrations where possible is emphasized by an article by R. E. PETERSON of Westinghouse Elec. & Mfg. Co. ("Some Examples of Failure Due to Stress Concentration", *Ibid.*, pp. 624-625). Several typical fatigue failures that have been observed in practice are illustrated and discussed.

It is noted in a case of a gear tooth that the fatigue cracks are located at exactly those points at which they may be expected from photoelastic studies. In several other cases the need for photoelastic analysis of the stress conditions is emphasized. The examples given include gear teeth, keyways, flanged shafting, and crankshafts. HFK (4)

Spectro-Analysis of Tiny Areas

A METHOD FOR THE SPECTRUM-ANALYTICAL EXAMINATION OF SMALL AREAS ("Ein Verfahren zur spektralanalytischen Untersuchung kleiner Flächenelemente") G. THANHEISER & J. HEYES. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch. Düsseldorf*, Vol. 23, No. 3, 1941, pp. 31-39. Descriptive.

Spectroscopy is useful in cases where it is desirable to have a knowledge of the composition or the distribution of elements over very small areas of a surface, *e.g.* a few thousandths of a mm.[2]

This recently developed method uses a thin mica foil with holes of 0.01-0.02 mm., which is placed over the surface (or cemented on) through which the spark is directed to the surface. Preferably a d.c. arc is used for the production of the spectrum. A number of examples are reproduced in photographs. Ha (4)

Metallographic Standards

EVALUATION OF METALLOGRAPHIC TESTS BY MEANS OF STRUCTURAL STANDARD SERIES (Auswartung metallographischer Werkstoffprüpungen durch Gefüge-Richtreihen") HANS DIERGARTEN. *Maschinenbau-Betrieb*, Vol. 19, Dec. 1940, p. 525-527. Practical.

In order to use metallographic tests for current inspection in production it is necessary to agree on a scale of classifications. For the grain size this can be done easily by comparison with a standard series of micrographs.

Each standard structure is given a number. The same system may be used for temper conditions, inclusions, hardening structures, slag contents, segregation, etc. A system of classification by means of numbers in decimal arrangement is suggested.

An inspector is able to run about 200 tests a day; and the results can be easily compared and evaluated by the engineer in charge. RPS (4)

Shear Strength and Test Velocity

THE INFLUENCE OF TESTING VELOCITY ON SHEARING STRENGTH OF LIGHT METAL RIVETING WIRE ("Der Einfluss der Prüfgeschwindigkeit auf die Scherfestigkeit von Leichtmetall-Nietdraht") K. MATTHAES. *Aluminium*, Vol. 23, Mar. 1941, pp. 156-159. Investigation.

Experiments made some time ago by other authors on the behavior of light metal riveting wire indicated a definite influence of testing velocity on the shearing strength, which showed differences of 50% between highest and lowest value for changes in shearing velocity of only 1:2.

As no definite reason for this behavior could be found, the experiments were repeated over a much wider range of testing velocity—from 0.7 to 317,000 sec., corresponding to shearing velocities of 0.0004 to 184 mm./min. The wires used were 3 and 5 mm. thick of hardened aluminum-copper-magnesium alloy.

No pronounced influence of testing velocity could be established in these tests; the individual value of shearing strength showed only ±2% difference. It is assumed that the differences found in former tests must be ascribed to errors of indication in the testing machine. Ha (4)

trends

By Edwin F. Cone, Editor

Air Conditioned Blast Furnaces

The application of air conditioning to American blast furnaces gains momentum. The Inland Steel Co. has ordered complete equipment to air condition one of its Indiana Harbor stacks. On top of or simultaneously with this comes the announcement that the Jones & Laughlin Steel Corp., as a result of the application of this system to three of its furnaces, will service approximately all of its 11 stacks with this air conditioning equipment. It is understood that pig iron yield on a tonnage basis has been increased 8 per cent at one furnace. By expanding the installations to 11 furnaces, the company is stated to expect that it will produce additional tonnage equivalent to that of a new blast furnace.

Open-Hearth Steel Capacity

As of June 30, 1941, the total capacity for producing steel in open-hearth furnaces is officially reported as 76,097,130 net tons per year, a new peak. From 1930 to 1935 the capacity was fairly stationary at 66,600,000 to 69,000,000 tons. At the end of 1925 or 15½ years ago it was 53,570,631 tons, thus making the expansion in that period about 42 per cent.

Another Society Exhibition

The list of technical societies which hold exhibitions has been increased. The Electrochemical Society announce "an extensive industrial exhibit, educational in character" as an integral part of the fall convention in Chicago, Oct. 1 to 4, at the Hotel Knickerbocker.

Tin

World production of tin for the first half of this year is reported as 125,000 tons against 105,200 tons for the same 6 mos. in 1940. Deliveries to the United States totaled 80,372 tons to July 1, 1941, as compared with 50,609 tons for the same period a year ago.

Magnesium Alloys

Dr. R. H. Harrington of the General Electric Co. states that the present trend in the application of magnesium alloys is for—crankcases and covers, breather caps, supercharger parts, carburetor parts, manifolds, body parts for coal drills, portable polishing tools and drills, vacuum cleaner parts, light-weight bearings of low load carrying capacity, oil pumps, airplane wheels, reciprocating parts in printing presses, rotating parts in fans and blowers; panels, cases and fittings for portable instruments; bus doors, frames for fish nets, parts for grinders and sanders; light structural framework, fuel tanks, housings, furniture, trimmings, and small die cast parts such as door handles.

Magnesium

The present remarkable expansion in the production of magnesium is being made possible by new plants using sea water as a source of the metal, says Dr. R. H. Harrington, metallurgist, General Electric Research Laboratory. Present output points to a yield of 30,000,000 lbs. for 1941 and nearly 90,000,000 lbs. in 1942—from 6,000,000 to 90,000,000 lbs. in 3 yrs.

More Steel Castings

Production of steel castings in the United States is increasing. For the first 6 mos. of this year the output of commercial castings, as reported by the Bureau of Census, U. S. Dept. of Commerce, has been 596,022 net tons (84.9% of capacity). This contrasts with 358,767 tons (51.1% of capacity) to July 1, 1940, and only 236,378 tons (33.7%) to July 1, 1939. The contrast between the present period and the same one in 1939 is striking.

Selenium

There has been a "fabulous" increase in the use of pure refined selenium, says a report of the International Telephone and Telegraph Corp. The increase has been 100-fold this year over last. While one of the lesser known of the elements, it is employed in making red glass, certain pharmaceutical products, and particularly in selenium rectifiers. These are being used extensively by various National Defense suppliers.

Bessemer Steel Capacity

Despite the statement that, owing to the fact that one Bessemer converter, installed largely for experimental purposes was dropped from the list in the last 6 mos., the Bessemer capacity has declined about 3 per cent since Dec. 31, 1940, it is probable that the trend will be upward in future official reports. Present converters are being enlarged and new ones will likely be installed.

Bauxite Consumption

All previous records in the domestic consumption of bauxite were exceeded in 1940 at 958,695 gross tons—22 per cent greater than the 782,975 tons in 1939, the previous peak year. Domestic shipments contributed 47 per cent and net imports 53 per cent of the total 1940 apparent consumption.

(Additional "Trends" on page 666)

trends

By Edwin F. Cone, Editor

Capacities Expand

Expansion in both steel making and pig iron capacity of the country is a feature of present developments. The American Iron and Steel Institute reports that during the first half of 1941, the steel making capacity has increased almost 2,000,000 tons, making a total increase of nearly 4,500,000 tons in the 18 months, Jan. 1, 1940 to July 1, 1941. The capacity as of June 30, this year, is 86,148,700 net tons.

There has been an increase in blast furnace capacity of 300,000 tons during the first half of this year so that the rated capacity as of June 30, 1941, is 57,937,000 tons of pig iron and ferroalloys.

Of the expansion in steel capacity placed in operation this year, 1,500,000 tons was open-hearth and 686,000 tons electric furnace steel.

Malleable Iron Castings

The production of malleable iron castings this year shows a decided increase over that of recent years. According to the U. S. Dept. of Commerce, the output to Aug. 1 this year has been at the rate of about 68,990 net tons per month as compared with 47,160 tons per month for all of 1940, with 40,050 tons each month for all of 1939 and with 50,190 tons per month for the year 1937. The increase for this year to May 1 over the 1940 rate is nearly 46.5 per cent.

Aluminum, Past and Present

Fifty years ago, when aluminum was first produced by the Aluminum company, the price was $8 per lb. Today as a result of a vast expansion in output, it is now 15c a lb. Five decades ago the output was only 9,000 lbs. a year; when present new plants are operating it will soon total 1,100,000,000 lbs. a year, says an announcement of the company.

New Alloy for Airplanes?

Will aluminum alloys have to be displaced by a stronger material in airplanes? Dr. John E. Younger, aeronautical engineer and winner this year of aviation's coveted award, the Spirit of St. Louis gold medal, is reported in the daily press to have concluded that these alloys will have to be displaced by a stronger material, possibly steel, to withstand the terrific stress of faster flying. He is reported to be convinced that the present all-metal plane of aluminum alloy construction is not the ultimate in aircraft design, and he suggests that private industry or the Federal Government sponsor university research laboratories to study new methods of building aircraft.

A New Spark Plug

According to a patent granted to John H. Dillon of Akron, Ohio and assigned to the Firestone Tire & Rubber Co. of that city, a radioactive spark plug for auto engines will reduce gasoline consumption, and give quicker starting and more power. The feature is a plating or alloy of a radioactive metal, such as polonium, on one or both of the electrodes across which jumps the spark that explodes the gasoline in the cylinders. Instead of having a coating, the electrodes may be made from an alloy of nickel and a radioactive metal such as polonium.

Steel for Auto License Plates

Michigan authorities announce that smaller automobile license plates will be adopted in 1942 to conserve steel. The saving in the production of 2,261,560 sets of plates, the total for last year, will be 287,304 lbs.

Similar steps are under consideration for other states. In the case of New York, a substantial saving is possible.

Cadmium

During 1940 a new high was recorded in the apparent domestic consumption of cadmium at 6,666,000 lbs. This is 13 per cent greater than the total in 1937, the previous peak year.

Production of the metal in 1940 was also a new total at 5,921,488 lbs.

As might be expected, imports of cadmium were sharply lower last year—or only 27,491 lbs. against 309,874 lbs. in 1939.

With 717,000 lbs. more Cd used than was produced and imported, suggestions for substituting Sn in solder by Cd do not look very useful, since there is already a red ink balance.

Fluorspar

Operations at American steel mills and aluminum plants expanded so much last year that the demand for fluorspar resulted in total shipments from domestic mines attaining to the second highest on record. The U.S. Bureau of Mines states that domestic mine production was 41 per cent higher and shipments 28 per cent greater in 1940 than in 1939. The record for 1941 is likely to surpass last year's.

(Additional "Trends" on page 664)

Metals and Alloys

THE MAGAZINE OF METALLURGICAL ENGINEERING

PRODUCTION · FABRICATION · TREATMENT · APPLICATION

NOVEMBER 1941